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Mechanical Ventilation: Relationship Between Body Mass Index and Selected Patients' Outcomes at a University Hospital in Cairo

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Abstract
Background: Mechanical ventilation is a life-saving management approach for critically ill patients. However, it has certain negative consequences which may affect patients' outcomes. Among factors that could adversely influence the prognosis of these patients is the body mass index (BMI). **Aim of the study:** to investigate the relationship between BMI and selected outcomes of critically ill mechanically ventilated patients. **Research Design:** A descriptive correlational research design was utilized **Research questions: a)** what is the BMI profile of mechanically ventilated patients admitted to critical care units over a period of six months? **b)** What is the relationship between body mass index and frequency of organ dysfunction, length of ICU stay, weaning from mechanical ventilation, and the mortality rate among adult critically ill mechanically ventilated patients? **Setting:** different intensive care units of a university hospital in Cairo. **Sample:** A purposive sample of 30 critically ill patients connected to mechanical ventilators for at least 72 hours. **Tools of data collection:** Three tools were utilized to collect data pertinent to the current study: **tool 1:** patients' demographic and medical data, **tool 2:** BURNS Wean Assessment Program (BWAP) checklist, **tool 3:** Sequential Organ Failure Assessment (SOFA score) tool. **Results:** More than three quarters (77%) of the studied sample were males, and more than one quarter (26.7 %) were in the age group of 18-28 and 40-50 years old respectively, with a mean age of 39.766 ± 13.51. Two thirds (66.7%) of the studied sample had normal BMI. No significant statistical relationship was found between BMI and ICU length of stay and mortality rate among the studied sample, (X^2= 11.31, P value $\leq$ 0.79), (X^2 = 0.15, P value $\leq$ 0.928) respectively. No significant statistical relationship was found between BMI and the weaning trials from mechanical ventilation (X^2= 0.15, P value $\leq$ 0.928). No significant statistical relationship was found between BMI and the occurrence of organ dysfunction (X^2 = 2.54, P value $\leq$ 0.637). **Conclusion**: BMI in the current study was not found to have relationship to weaning from MV, length of ICU stay, occurrence of organ failure, and mortality rate. **Recommendations**: Nutritional status of critically ill mechanically ventilated patients must be considered in their management; meticulous nutritional assessment must be done for all critically ill mechanically ventilated patients to enable in monitoring their progress and outcomes; development of a comprehensive assessment tool that facilitates inspection and early detection of problems/complications among mechanically ventilated patients' documentation system must include patients' nutritional assessment data such as anthropometric measurements (height, weight) to facilitate calculation of BMI.
Keywords: Mechanical ventilation, body mass index, organ dysfunction, length of ICU stay, weaning from mechanical ventilation, mortality rate

1. Introduction:

To depend on mechanical ventilation after critical illness is a challenge; however, long-term outcomes are incompletely understood .Body weight changes daily throughout a patient's stay in the intensive care unit (ICU) as a result of many factors including fluid balance, nutritional status, type of acute illness, and presence of comorbidities. The ICU nurse should be able to evaluate factors related to mortality and the association between changes in body weight and clinical outcomes, including duration of mechanical ventilation (MV), length of ICU stay, and ICU mortality **(You, et al, 2013).** As indicated by **Anzuoto, et al (2010)**, there is no differences in the mechanically ventilated patients' outcomes (duration of weaning from mechanical ventilation, length of stay in the hospital, ICU length of stay, and the mortality rates) based on body mass index (BMI) categories.

However, **Westerly & Dabbagh, (2011)** revealed that, the more BMI is, the more patients' need for ICU admission and mechanichal ventilation, longer hospital length of stay, and more chances for tracheostomy placements; but there is no significant change in the mortality rates. Obesity is associated with an inflammatory condition that leads to an immunodeficient state. An immuno-deficient state can be a result from an inflammatory condition caused by obesity. Obese traumatic patients are more liable to infection compared to ones of normal BMI **(Serrano, & Khuder, 2010).** In addition, **Morton & Fontaine, (2013)** reported that, mechanically ventilated patients need special and comprehensive nursing care to decrease the costs, length of

stay, and mortality rates, in addition, the critically ill patients has more metabolic needs, so that, nutritional support is very essential to help the respiratory muscles to overcome fatigue.

Mechanically ventilated patient's stability and readiness for weaning should be screened daily before starting the weaning process. There are many factors affecting the weaning process such as: the lungs ability to participate in ventilation, cardiovascular performance, and finally the psychological readiness. The rapid shallow breathing index and weaning intolerance indicators can help to predict the weaning success **(Urden, Stacy, & Lough, 2012).** When caring for a mechanically ventilated patient, the ICU nurse should focus the nursing intervention on maximizing the oxygenation and ventilation, and prevention the complications of artificial airways and mechanical ventilation. He/she should maintain the optimal communication ways with the patient to reduce anxiety and maximize the psychological support **(Chulay& Burns, 2010).**

2. Significance of the study

It has been observed over a period of 3 years as a clinical instructor at the critical care unit that mechanically ventilated patients experience many problems, of these are difficulty in weaning from mechanical ventilators, prolonged stay in the ICU, repeated mechanical ventilation after disconnection. These problems were most frequent among obese and underweight patients. However **Anzuoto, et al, (2010)** revealed that, there are limited data on the impact of body mass index on outcomes of mechanically ventilated patients. Therefore, this study will be carried out on an attempt to investigate the relationship between BMI and outcomes of critically ill mechanically ventilated patients at Cairo university hospitals as indicated by frequency of organ dysfunction, length of ICU stay, weaning from mechanical ventilation, and the mortality rate.

3. Aim of the study

The aim of this study is to investigate the relationship between BMI and selected outcomes of critically ill mechanically ventilated patients at a university hospital in Cairo as indicated by frequency of organ dysfunction, length of ICU stay, weaning from mechanical ventilation, and the mortality rate.

4. Research Questions:

To fulfill the aim of this study the following research questions were formulated:

Q1: What is the body mass index profile of mechanically ventilated patients admitted to critical care units over a period of six months?

Q2: What is the relationship between body mass index and frequency of organ dysfunction, length of ICU stay, weaning from mechanical ventilation, and the mortality rate among adult critically ill mechanically ventilated patients?

5. Subjects and Methods:

5.1. Research Design

A descriptive correlational research design was utilized in the current study. Descriptive correlational research is used to describe the relationships among variables rather than to support inferences of causality **(Polit & Beck, 2012).**

5.2. Setting

The current study was carried out at different intensive care units of Cairo University Hospitals. These units were: Critical Care Medicine Department (first & second units) which consists of 12 ICU beds and 9 CCU beds in the first floor and 23 ICU beds in the second floor. Also the Critical Care Medicine Department (the third unit) at Al-Manial Specialized University Hospital in the 4th floor consists of two rooms, the first room consists of 15 ICU beds, and the second one consists of 10 ICU beds. In addition, the emergency ICU in section 5 at Kasr Al-Aini Hospital consists of 12 ICU beds. Finally, the ICU at the 185 Kasr Al-Aini Hospital for Burn and Emergency which consists of 20 ICU beds.

5.3. Subject

A purposive a sample of 30 adult male and female patients admitted to the ICU and connected with the mechanical ventilator for at least 72 hours with age ranges from 18-60 years. The study was carried out at the intensive care units affiliated to Cairo University Hospitals, in Cairo governorate from March 2014 to September 2014.

5.4 Tools

Three tools were utilized to collect data pertinent to the current study: demographic and medical data sheet, BURNS Wean Assessment Program (BWAP) checklist, and Sequential Organ Failure Assessment score (SOFA score).

Three tools were utilized for data collection; one of these tools was designed by the investigator (demographic and medical data tool), and the other two tools were adopted (BURNS Wean Assessment Program (BWAP) checklist, and sequential organ failure assessment tool (SOFA score)) then reviewed by a panel of three experts. These tools were:

5.4.1 Socio demographic and medical data tool: This included the patient's age, gender, diagnosis, co-morbidity disease, and length of ICU stay ….etc.

5.4.2. BURNS Wean Assessment Program (BWAP) checklist: This tool was developed by Burns S.M. (1990). It provides a more comprehensive assessment of weaning readiness. It is used to systematically assess and track weaning progress for the mechanically ventilated patients through general and respiratory assessment. The BWAP is a 26 item checklist, and covers two major areas of assessment:

A: General assessment of the patient (12 items).

B: Respiratory assessment which contains 14 items (gas flow and work of breathing, airway clearance, strength, endurance and arterial blood gases)

5.4.3. Sequential organ failure assessment tool: This tool was adopted from Vincent (1996). It is a scoring system used to determine the extent of organ dysfunction or rate of failure during stay in the intensive care unit. It was designed to provide simple score that indicates how the status of the patient evolves over time. The assessment is based on six different scores, one for the respiratory, cardiovascular, hepatic, coagulation, renal and neurological systems. The SOFA score is reliable, valid, and effective method to describe organ dysfunction/failure in critically ill patients. Regular and repeated scoring help in monitoring patients' condition and disease development. Each organ is graded from 0 (normal) to 4 (the most abnormal), providing score of 0 to 24 points, the greater the score, the worse the condition.

5.5. Ethical consideration

An official permission to conduct the proposed study was obtained from the research ethical committee and from hospital administrators to conduct the study. Participation in this study was entirely voluntary; each patient /relative had the right to accept participation in the study or not. Informed consent was obtained from trauma patient or their relatives. Anonymity and confidentiality were assured through coding the data, every participant had the right to withdraw from the study at any time; subjects were assured that the data will not be reused in another research without second /other new permission

5.6. Procedure:

The study was conducted through two phases: designing phase and implementation phase.

1.Designing phase:

It involved construction of different data collection tools, obtaining official agreements to conduct the study, then, it was ended by conduction of the pilot study. After obtaining the official permission to proceed with the proposed study, actual implementation was initiated by obtaining a list of patients who admitted to critical care departments and connected with mechanical ventilators, and met the inclusion criteria. Then patients/relatives (in case of unconscious patient) who agreed to participate in the study were interviewed individually by the investigator to explain the nature and purpose of the study. A pilot study was carried out on five patients admitted to the ICU to test feasibility, objectivity, and applicability of the data collection tools and the five patients of the pilot study were included in the current study.

2. Implementation phase:

Data of the current study were collected from March 2014 to September 2014, once official permissions were granted. A total number of 30 patients who fulfilled the criteria of inclusion were recruited into the present study. The investigator obtained patients' socio demographic and medical data utilizing sociodemographic and medical data sheet. Based on patients' BMI, they were classified into three groups according to the BMI score (underweight, normal, obese). Then the investigator utilized BURNS Wean Assessment Program (BWAP) checklist to assess the patients' ability to initiate spontaneous breathing and monitor the weaning pattern from mechanical ventilator on daily basis. To utilize this checklist the investigator should be aware about the criteria of each item to be able to check (Yes, No, or No assessed). This checklist may take 15-20 minutes to fulfill; the most of data was recorded at the patient's file as the investigator relies on the previous 24-hour data. Then, the investigator assessed the occurrence of organ dysfunction by utilizing the SOFA score, this sheet was filled out through repeated visits to each included patient: on admission, and every 48 hours, then after 96 hours from admission until discharge from the ICU.

5.7. Statistical data analysis:

The collected data were scored, tabulated and analyzed by personal computer using statistical package for the social science (SPSS) program version 21. Descriptive and inferential statistics were done such as mean and standard deviations; frequency; percentage; chi square test; independent t test; and analysis of variance

(ANOVA). Level of significant will be set at p≤0.05.

6. Results:

Statistical findings of the current study are presented in two main sections: first section will describe the studied sample as regards to their socio-demographic and medical data (figures 1-6). The second section answering the research questions tables (1- 6).

Section 1:

Figure (1) shows that, (26.7 %) of the studied sample were in the age group of 18-28 years old, and (26.7 %) were in the age group of 40-50 years old. Figure (2) shows that more than three quarters of the studied sample (77%) was males. Figure (3) shows that two thirds (66.7%) of the studied sample had within normal BMI. Figure (4) shows that more than three quarters (76.7 %) of the studied sample had received continuous mandatory ventilation mode. Figure (5) illustrates that two thirds (66.7 %) of the studied sample had difficult weaning from mechanical ventilators. Figure (6) shows that, 50 % of the studied sample stayed from 7 to14 days in the ICUs.

Section 2:

Table (1) revealed that, (no significant statistical relationship between BMI and ICU length of stay among the studied sample, (X2= 11.31, P value = 0.79). Table (2) reveals that, two thirds of the studied sample died during their stay in the ICU. No significant statistical relationship between BMI and the mortality rate among the studied sample, (X^2 = 0.15, P value = 0.928).

Table (3) reveals that no significant statistical relationship between BMI categories and the weaning trials from mechanical ventilation among the studied sample, (X^2 = 0.15, P value= 0.928).

Table (4) reveals that more than three quarters of the studied sample (76.7%) had mild organ dysfunction. No significant statistical relationship was found between BMI categories and the occurrence of organ dysfunction among the studied sample, (X^2 = 2.54, P value ≤ 0.637).

Table (5) reveals that there is a significant statistical negative correlation between the mean SOFA scores and the mean BWAP scores, and between the mean SOFA scores and length of ICU stay (r / P = -0.663/0.000, -0.362/0.049) respectively. However, no significant statistical correlations were found between ages, days of mechanical ventilation, mean of SOFA, mean of BWAP, and length of ICU stay.

Table (6) illustrates that no significant statistical relation between BMI categories, mean BWAP score, mean SOFA score, and length of ICU stay value, (F/P = 0.631/0.540, 0.519/0.601, 0.087/0.917) respectively.

(A). Figures:

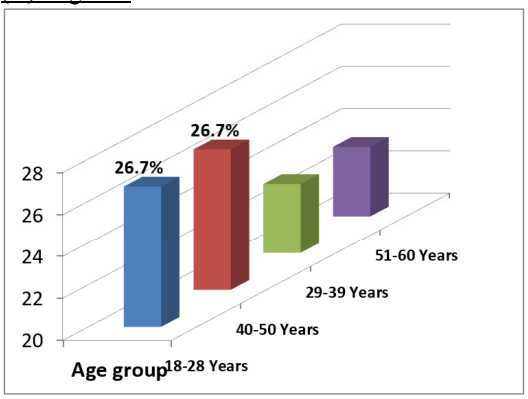

Figure 1. Percentage Distribution of the Studied Sample as Regards to Age Group, (N=30)

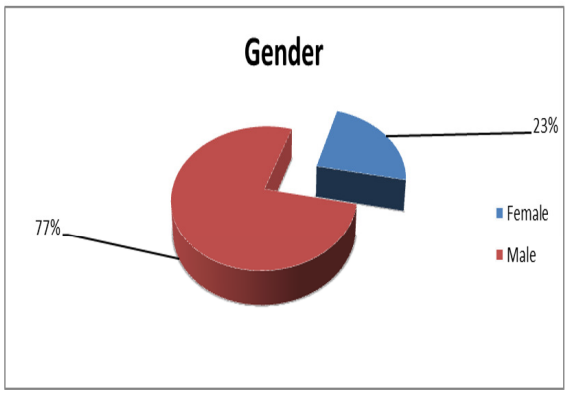

Figure 2. Percentage Distribution of the Studied Sample as Regards to Gender, (N=30)

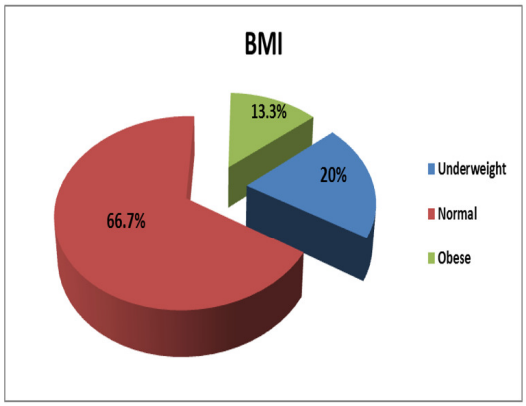

Figure 3. Percentage Distribution of the Studied Subjects as regards to BMI, (N=30)

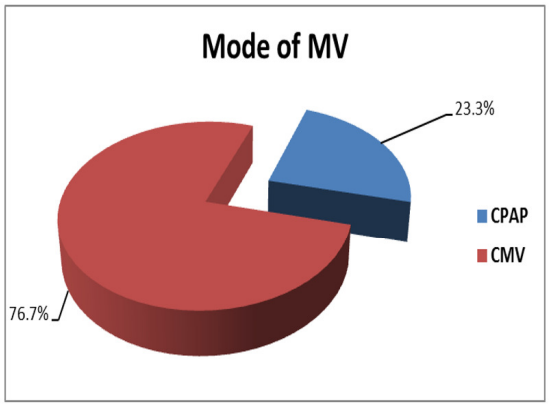

Figure 4. Percentage Distribution of the Studied Sample as Regards to Mode of MV, (N=30)

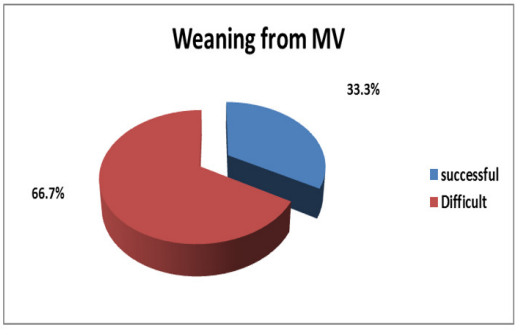

Figure 5. Percentage Distribution of the Studied Sample as Regards to Fate of Weaning from MV, (N=30).

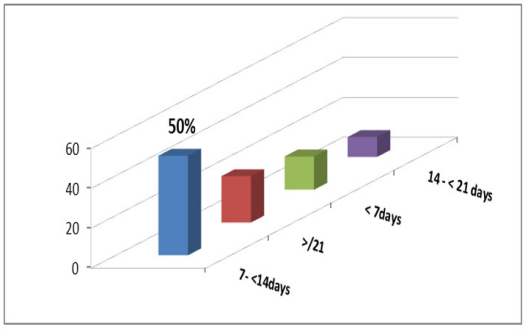

Figure 6. Percentage Distribution of the Studied Sample as Regards to Length of ICU Stay, (N=30)

(B) Tables:

Table 1Relationship between BMI Categories and Length of ICU Stay among the Studied Sample, (N= 30).

BMI / Length of ICU stay	BMI categories						Total		(X^2)	P value
	Underweight		Normal		Obese		No.	%		
	No.	%	No.	%	No.	%				
1. < 7 days	1	3.3	3	10	1	3.3	5	16.7	11.31	0.79 NS
2. 7 - < 14 days	2	6.7	12	40	1	3.3	15	50		
3. 14 - < 21 days	1	3.3	0	0	2	6.7	3	10		
4. >/21	2	6.7	5	16.7	0	0	7	23.3		
Total	6	20	20	66.7	4	13.3	30	100		

Table (2) Relationship between BMI Categories and Mortality Rate among the Studied Sample, (N= 30).

BMI / Mortality rate	BMI categories						Total		(X^2)	P value
	Underweight		Normal		Obese		No.	%		
	No.	%	No.	%	No.	%				
1. Died	4	13.3	13	43.3	3	10	20	66.7	0.15	0.928 NS
2. Discharged	2	6.7	7	23.3	1	3.3	10	33.3		
Total	6	20	20	66.7	4	13.3	30	100		

Table (3) Relationship between BMI Categories and Weaning Trials from Mechanical Ventilation, (N= 30).

BMI / Weaning from M.V	BMI categories						Total		(X^2)	P value
	Underweight		Normal		Obese		No.	%		
	No.	%	No.	%	No.	%				
1. Successful	2	6.7	7	23.3	1	3.3	10	33.3	0.15	0.928 NS
2. Difficult	4	13.3	13	43.3	3	10	20	66.7		
Total	6	20	20	66.7	4	13.3	30	100		

Table (4) Relationship between BMI Categories and the occurrence of organ dusfunction (SOFA score) (N= 30).

BMI / SOFA score	BMI categories						Total		(X^2)	P value
	Underweight		Normal		Obese		No	%		
	No	%	No	%	No	%				
1. Mild organ dysfunction	6	20	14	46.7	3	10	23	76.7	2.54	0.637 NS
2. Moderate organ dysfunction	0	0	5	16.7	1	3.3	6	20		
3. Severe organ dysfunction	0	0	1	3.3	0	0	1	3.3		
Total	6	20	20	66.7	4	13.3	30	100		

NS: No significant statistical relationship

Table (5) Correlation between Age, Days of Mechanical Ventilation, Mean SOFA Sores, Mean BWAP Scores, and Length of ICU Stay, (N= 30.

		Age	Days of MV	Mean SOFA	Mean BWAP
Age	Pearson Correlation				
Days of MV	r : P :	0.193 0.306 NS			
Mean SOFA	r : P :	0.009 0.962 NS	-0.189 0.317 NS		
Mean BWAP	r : P :	0.207 0.272 NS	-0.115 0.544 NS	-0.663 0.000**	
Length of ICU stay	r : P :	-0.013 0.947 NS	0.836 0.000**	-0.362 0.049**	0.062 0.745 NS

** Correlation is significant at the 0.05 NS: Not Significant.

Table (6) Comparison of mean BURN score, SOFA score, and length of ICU stay in relation to BMI Categories (N= 30).

BMI categories \ X ±SD	Patient's outcomes		
	BWAP	SOFA	Length of ICU stay
	X ±SD	X ±SD	X ±SD
1. Obese	9.05 ± 4.64	6.425 ± 1.7	13 ± 7.53
2. Normal	10.46 ± 3.32	6.64 ± 3.95	15.55 ± 13.16
3. Underweight	11.53 ± 2.93	5 ± 1.77	16 ± 9.53
Total	10.49 ± 3.39	6.28 ± 3.39	15.3 ± 11.65
F. test	0.631	0.519	0.087
P. value	0.540 NS	0.601 NS	0.917 NS

NS: No significant statistical relationship

7. Discussion

The present study delineated the dominance of males, especially in the age group reflecting young and middle adulthood. This finding is merely in agreement with that of **Elshimy, Shash, Seddik, (2015)** who conducted a published study entitled as "Effectiveness of adjunctive inhaled colistin in treatment of ventilator associated pneumonia" and found that more than three quarters of the studied sample were men and old adults. From the investigator's point of view, the dominance of males in this age category could be the rational of increased incidence of road traffic accidents. This is of special concern especially where, it was reported by **Egyptian Central Agency for Public Mobilization** and Statistics that, there were 16381 motor car and trains accidents in Egypt during the year of 2013.

Moreover, the current study revealed that, two thirds of the studied sample had within normal BMI. This finding is in agreement with that **Anzuoto, et al, (2010)** who studied " influence of body mass index on outcome of the mechanically ventilated patients" and revealed that more than one third of the studied sample had within normal BMI. Also **Lee, Tefera, Colice, (2014)** conducted a published study about "The effect of obesity on outcomes in mechanically ventilated patients in a medical intensive care unit" and found that around two thirds of the studied sample were non-obese. In contrast, **Sakr, et al, (2012)** conducted a published study about the effect of overweight or obese on the decreased mortality among the critically ill patients and revealed the presence of obesity among more than two thirds of the studied sample.

The current study revealed no significant statistical relationship between BMI and the occurrence of organ failure among the studied sample. In spite of having the BMI of two thirds of studied sample within normal, one cannot neglect the minority of the studied sample who were obese. In this regards, **Druml, et al, (2010)** found a significant relationship between obesity and development of acute kidney injury (AKI), where they published a study about "Impact of BMI on the incidence and prognosis of AKI requiring renal replacement therapy". Moreover, **Ju, et al (2014)** conducted a published study on 468 critically ill patients and revealed that BMI is a possible indicator of AKI. The occurrence of AKI was more frequent in overweight patients than in underweight ones.

The current study revealed no significant statistical relationship between body mass index (BMI) and ICU length of stay among the studied sample. This finding is in congruence with that of **Anzuoto, et al, (2010)** who found no significant differences in length of ICU stay in relation to body mass index categories of the studied sample. In contrast **Shah, et al, (2013)** conducted a study about the effect of BMI on the ICU length of stay, and found BMI to be associated with the ICU and hospital length of stay. Another study was conducted by **Huang, et al, (2013)** who revealed that status asthmatics patients with higher BMI had longer ICU length of stay indicating that, the increased BMI may be a negative prognostic factor among those patients.

The current study revealed no significant statistical relationship between BMI and the weaning trials from mechanical ventilation among the studied sample. This finding is in congruence with the results of a published study conducted by **Anzuoto, et al, (2010)** who found no differences in the duration of mechanical ventilation, or the duration of weaning from mechanical ventilation in relation to body mass index categories. However, **Soh, et al, (2014)** conducted a study about "Predicting delayed ventilator weaning after lung transplantation: the role of BMI" and revealed that low BMI might be associated with delayed ventilator weaning among the studied sample.

Moreover, the present study delineated that, two thirds of the studied sample had difficult weaning from the mechanical ventilators. This finding is in agreement with that of **Jiang, et al, (2014)** who conducted a study about "Predicting weaning and extubation outcomes in long-term mechanically ventilated patients using the modified Burns Wean Assessment Program scores" and revealed difficult weaning among the majority of the studied sample. While **Perren, Brochard, (2013)** conducted a published study about "Managing the apparent

and hidden difficulties of weaning from mechanical ventilation" and revealed difficult weaning from mechanical ventilator among more than one third of the studied sample. Also, **Peñuelas, et al, (2011)** conducted a study about characteristics and outcomes of ventilated patients according to time to weaning from mechanical ventilation and found more than half of the studied sample had simple weaning from mechanical ventilation.

The current study revealed no significant statistical relationship between BMI and the mortality rate. This finding is in concordance with that of **Lim, et al (2010),** who conducted a study about the BMI as a prognostic factor of critical care. They found no significant statistical relationship between BMI and ICU mortality, while the ICU mortality was influenced more strongly by severity of illness and failed extubation rather than BMI. In addition, **Shah, et al, (2013)** conducted a published study entitled as "Increasing BMI correlates with ICU and hospital length of stay but not mortality" and found no statistical correlation between increasing BMI and the ICU mortality. Also, **Pickkers, et al, (2013)** conducted a published study entitled as "Body mass index is associated with hospital mortality in critically ill patients: an observational cohort" and they found an inverse relationship between BMI and the hospital mortality among critically ill patients, therefore the obese patients had the lowest risk of death.

Finally, the current study clarified no significant statistical relation between BMI, mean BWAP score, mean SOFA score, and length of ICU stay value. This finding in agreement with the results of a published study conducted by **Anzuoto, et al, (2010)** who found no differences in the mechanically ventilated patients' outcomes (duration of weaning from mechanical ventilation, length of stay in the hospital, ICU length of stay , and the mortality rates in the ICU and hospital) based on BMI categories. Unexpectedly, **Lee, Tefera, Colice, (2014)** conducted a published study and found the mechanically ventilated obese patients did not have worse outcomes than non-obese ones with no differences in outcomes.

8. Conclusion

Based on findings of the current study, it can be concluded that, in spite of the importance of BMI as an indicator of nutritional status, the current study revealed no significant statistical relationship between BMI and selected mechanically ventilated patients' outcomes (weaning from MV, length of ICU stay, occurrence of organ failure, mortality rate). In addition, the current study revealed that, the more the organ dysfunction scores (SOFA scores), the lesser the weaning possibilities from mechanical ventilation. The highest percentages of death were found among patients who were in the age group of 40-60 years, males, had within normal BMI, on CMV mode, and admitted with surgical, neurological, and cardiovascular emergencies. Unexpectedly, the greatest mean length of ICU stay was found among the underweight patients.

9. Recommendation:

Based on the findings of the present study, the following recommendations are suggested:

9.1. Recommendations related to patients:

- Nutritional status of critically ill mechanically ventilated patients must be considered in their management.
- Meticulous nutritional assessment must be done for all critically ill patients especially those who are mechanically ventilated to enable in monitoring their progress and outcomes.
- Development of a comprehensive assessment tool that facilitates inspection and early detection of problems/complications among mechanically ventilated patients.
- Patients' documentation system must include patients' nutritional assessment data such as anthropometric measurements (height, weight) to facilitate calculation of BMI.

9.2. Recommendations for furthers researches:

- Replication of the study on a larger probability sample selected from different geographical areas in Egypt is recommended to obtain more generalizable data.
- Study the relationship between BMI and development of organ dysfunction among critically ill patients.

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