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The ABCDE bundle to improve the clinical outcomes for mechanically ventilated patients

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Abstract

Background: The ABCDE bundle incorporates Awakening and Breathing Coordination, Delirium monitoring/management, and Early exercise/mobility to optimizing patient outcomes such as reduce duration of mechanical ventilation, ICU length of stay and improve hemodynamic status.

Aim of the study: was to examine the effect of ABCDE bundle on selected clinical outcomes among mechanically ventilated patients.

Setting: The study was conducted at Surgical Intensive Care Unit (SICU) at Menoufia University Hospital.

Sample: A convenient sample of 100 mechanically ventilated patients who were admitted to SICU.

Design: A quasi-experimental design was utilized.

Tools: (1) A Semi Structured Demographic Questionnaire, and (2) Cardiorespiratory Parameters questionnaire.

Results: there was a highly statistically significant decrease in the mean score of ventilator free days of the study group compared with the control group (6.10 ± 1.77) (4.70 ± 1.53) respectively (p<0 .002) post intervention. The mean ICU length of stay decreased in the study group compared to the control group post intervention (10.00 ± 2.67 and 14.70 ± 3.72) (p< 0 .001). Additionally there was a statistically significant difference in the mean values of hemodynamic and oxygenation parameters (MAP, HR, CVP RR, PaO_2, PH, $PaCO_2$ and S_aO_2) post intervention.

Conclusion: ABCDE bundle intervention improved selected clinical outcomes among mechanically ventilated patients.

Recommendation: Implementation of the ABCDE bundle as a routine nursing practice in the intensive care unit.

Keywords: ABCDE Bundle, Hemodynamic, Oxygenation, ICU length of stay, Mechanical Ventilation

Introduction

Mechanical ventilation (MV) is the cornerstone of management for many critically ill patients. It is the most used short-term life support technique worldwide. Approximately, 310 persons per 100,000 adult population undergo invasive ventilation in the United States [1].

Mechanical ventilation improve gas exchange, restore arterial blood acid-base balance, decrease the work of breathing and rest respiratory muscles, but it can cause physiological impairments such as reduce venous return, increase pulmonary vascular resistance, increase right ventricular afterload, shift the intraventricular septum to the left, and decrease left ventricular filling which lead to decrease cardiac output [2].

Mechanically ventilated patients are frequently immobilized for days due to their illness and sedation. Prolonged immobility can produce cardiovascular changes and hemodynamic instability. Immobility causes shifting and redistribution of fluids, increasing urine output, reducing in blood volume, increasing hematocrit and blood viscosity, reducing venous return, leading to reduce stroke volume, cardiac de-conditioning and postural hypotension upon remobilization [3]. Thus, monitoring the hemodynamic parameters is very important for mechanically ventilated patients, which can guide therapy and improve tissue perfusion.

Also, prolonged immobility causes changes to the respiratory systems including increased weight on ribcage which restricts breathing movements, reduced tidal volume, residual volume and forced vital capacity, and less-effective coughing reflex, increased pooling of mucus and damage to ciliary escalator, and increased respiratory tract infections [4].

Mechanical ventilation complications are directly related to the duration of MV and it is necessary to carry out interventions that decrease the duration of MV and minimize sedation [5]. The severity of these complications was also linked to the duration of delirium state. Therefore, prevention and early management of delirium is a crucial role to minimize the adverse effects on clinical outcomes

associated with ICU- acquired delirium among at-risk identified patients [5].

Awakening and Breathing Coordination, Delirium monitoring/management, and Early exercise/mobility (ABCDE) bundle incorporates the best evidence based practice related to sedation, delirium, immobility and ventilator management [6]. ABCDE bundle is a multi-component intervention associated with shorter duration of mechanical ventilation and minimizing adverse outcomes for mechanically ventilated patients [7].

Early mobility which is an integral part of the ABCDE bundle has demonstrated improvements in hemodynamic and oxygenation status [8]. Early exercise and mobility resulted in improving the respiratory muscle strength, decreasing mucus viscosity, activates and releases lipoproteinase on the alveolar wall, relieves bronchial spasm, and alleviate the inflammatory exudation of lung tissues which improves the ventilation/perfusion ratio and the circulatory function [9].

Also, It has been demonstrated that patients who receive coordinated awakening and spontaneous breathing trials experience improvement in cardiopulmonary status and less ICU length of stay and more ventilator free days [10]. The Spontaneous Breathing Trial (SAT) facilitates weaning from mechanical ventilation which reduce duration of mechanical ventilation and decrease ventilator induce hemodynamic instability [11].

Deep sedation is necessary for mechanically ventilated patients to manage agitation and distress, ventilator synchronization, and enables patients to tolerate painful procedures [12]. Continuous deep sedative medications can cause respiratory depression, hemodynamic instability, and metabolic acidosis, and delirium which prolong the duration of mechanical ventilation and ICU length of stay [13]. Additionally, sedative agents may inhabit the sympathetic nervous system, resulting in reducing myocardial suppression which results in hemodynamic consequences. Therefore, the optimal use of sedative agents can enhance hemodynamic state, reduce stress response, decrease oxygen consumption, and improve patient comfort [14].

The effect of ABCDE bundle implementation has been proven to be safe and effective for mechanically ventilated patients and can improve hemodynamic and enhance oxygenation index [15].

Significance of the Study

Mechanical ventilation can cause physiological and psychological impairments that require long-term management [16]. Few studies focused on examining the effect of integrated, interprofessional interventions to symptom management of critically ill patients. The ABCDE bundle focuses on symptom assessment, prevention, and management rather than disease processes and is appropriate for use in combination with other life-sustaining therapies.

Critically ill patients experience adverse symptoms including agitation, delirium, weakness, and sleep deprivation. The complexity and severity of these symptoms requires keeping these patients sedated and immobilized most of the time. Sedation can lead to delirium and cognitive impairment. Delirium have been associated with increasing duration of mechanical ventilation, ICU length of stay, and increased mortality.

The ABCDE bundle is a unique team-based approach aimed to help patients to be more awake, cognitively engaged, and physically active. All of which ultimately serves to assist patient self-sufficiency and the ability to express his/her physical and emotional needs. There are substantial evidence to support the safety and efficacy of the implementation of the ABCDE components during caring of the critically ill patients [17, 18, 19]. The ABCDE bundle implementation holds potential for numerus benefit to mechanically ventilated patients which include reducing delirium, increasing ventilator free days, reduced ICU length of stay and improve hemodynamic status. Several studies on ABCDE bundle has focused on the prevention of delirium and ICU-acquired weakness. However, few studies examined the effect of implementation of the ABCDE bundle on hemodynamic. Therefore, the current study examined the effect of the ABCDE Bundle on oxygenation and hemodynamic status.

Aim of Study

To examine the effect of ABCDE Bundle on selected clinical outcomes among Mechanically Ventilated Patients

Research Hypotheses

1. The patients who receive ABCDE Bundle intervention are more likely to have improved oxygenation and hemodynamic parameters than the patients who do not receive the ABCDE Bundle intervention.
2. The patients who receive ABCDE Bundle intervention are more likely to experience less duration of mechanical ventilation and less ICU length of stay than the patients who do not receive the ABCDE Bundle intervention.
3. The patients who receive ABCDE Bundle intervention are more likely to have fewer sedatives prescribed than patients who do not receive the ABCDE Bundle intervention.

Methods

Research Design: A quasi experimental design was utilized to achieve the aim of the study.

Setting: The current study was conducted in the Surgical Intensive Care Unit at Menoufia University hospital, Menoufia, Egypt.

Sample: A convenient sample of 100 patients was recruited to participate in the current study. Patients who met the study inclusion criteria including: a) Adult patients (18-65 years); b) Patients stayed in the ICU more than 24 hours; and c) Mechanically ventilated patients on sedation. Patients were excluded from participation in the study if they have any of the following conditions: a) Quadriplegia; b) Neuromuscular diseases (Guillain–Barré Syndrome, Myasthenia Gravis, Peripheral Neuropathy) that could impair weaning from MV; c) Richmond Agitation-Sedation Scale score of -4 and -5 (Deep coma) without sedation because patients cannot obey commands; d) Deep Vein Thrombosis; and e) Status epileptics.

Sample Size Calculation: Sample size was calculated based on the power analysis technique. A previous study indicated that 88 patients would yield a sufficient statistical power of 80% to detect the effect of the ABCDE bundle on ICU acquired delirium and weakness among mechanically

ventilated patients using a medium effect size of 0.05 and Alpha level was set at 0 .05 [20, 21]. Twelve patients were added to compansate for the attreation rate in this population [21]. Thus, the final sample size was decided to be a 100 patients.

Instrument

i) A Semi Structured Demographic and Clinical Data: A Semi Structured demographic clinical data sheet was developed by the researcher to collect data about age, gender, ICU diagnosis, ventilator free days and ICU length of stay.
ii) Cardiorespiratory Parameters Questionnaire was developed by [22] to assess oxygenation and hemodynamic status of the patients. oxygenation parameters including respiratory rate, PH, arterial partial pressure of oxygen (PaO_2), Arterial blood sample was drown from patient and was analyzed via blood gas analyzer (RAPID Point® 500). The Reliability of the Rapid Point 500(®) was evaluated by the inter assay coefficients higher than 0.91 [23]. The Validity of the Rapid Point 500(®) was assessed over a 20 day period by the correlation coefficients and showed a significant relationship (r = 0.96) [24].

Hemodynamic parameters including Central Venous Pressure (CVP), Heart Rate, and Mean Arterial Pressure (MAP) were obtained from the bed side monitor (NIHON KOHDEN, life scope, BSM 3000 series, Tokyo, Japan). The CVP was measured manually. The Reliability of the bed side monitor (NIHON KOHDEN, life scope, BSM 3000 series) was tested by Cronbach's co-efficiency Alpha (a=.0.87). The Validity of the machine had an RR accuracy of 93.1% and an HR accuracy of 94.4% among ICU patients [25].

Ethical Consideration

The permission for conducting the study was obtained from the Ethic Committee of the Faculty of Nursing and hospital director to carry out the study after explaining the purpose of the study. An oral consent was obtained from the patients' relatives. In the initial interview, the relatives were informed about the purpose, procedure, and benefits of the study. The researcher explained that participation in the study is voluntary and they can withdraw from the study at any time without penalty. Confidentiality and anonymity of patients' information were assured through coding all data and put all paper in a secured closed cabinet. Questionnaires were fulfilled by the investigator and the nature of questionnaires didn't cause any physical or emotional harm to the participants.

Data Collection Procedure

Data were collected over Eight months from the beginning of June 2020 to the end of January 2021. The Participants were recruited to participate in the study on the first day of admission to the SICU. The Participants were matched against the study inclusion criteria. The control group followed the usual hospital care. The study group received the ABCDE bundle intervention.

The ABCDE Bundle Intervention (Study Group)

Coordination of Awakening and Breathing Trial

The patients have a Spontaneous Awakening Trial (SAT) every 24 hours after a successful SAT safety screening. If the patient fail to pass the SAT safety criteria such as no seizures and agitation, no alcohol withdrawal, no paralytic agents/neuromuscular blocking agents, no myocardial infarction in the past 24 hours, normal ICP, the patient's sedation regimen are continued and reassessed after 24 hours. If the patients pass the SAT safety screening, the researcher stopped the sedative medication. During the period of rest from sedation, the patient is screened for any failure criteria. If the patient experiences any of the SAT failure criteria, the researcher restarted the sedation at half of the previous dose and then patient reassessed for awakening trail after 24 hours.

If the patient was able to respond to verbal stimulation and tolerated the discontinuation of the sedatives, Spontaneous Breathing Trial (SBT) Safety Screen was performed. If the patient has not met the previous SBT Safety Screen criteria, the SBT was not started and the mechanical ventilation was continued. The SBT Safety Screen criteria were reassessed after 24 hours. If the patient tolerated the SBT for 30–120 minutes without manifesting any of the failure criteria, this indicates that the patient has passed the SBT and extubation was considered.

Delirium Monitoring and Management

Patients with a RASS score of −3 or higher underwent delirium screening with (CAM-ICU) daily every 8 hours. If delirium was detected, possible causes and risk factors were assessed and non-pharmacologic management strategies were used to manage delirium.

Early Exercise/Mobility

Passive Range of Motion exercise (PROM) was performed once daily to all upper and lower extremity joints. Patients were progressed to active-assistive and active range of motion exercise as they are alert and able to advance their participation. If the patient passes the mobility safety screen criteria, patient was mobilized at least once a day.

Statistical Analysis

Data was collected, tabulated, and statistically analyzed. Descriptive Statistics **(**Arithmetic Mean (X) and Standard Deviation (SD)) and Analytic Statistics **(**Student t-test and Paired t –test) were used to present the findings. For all the statistical tests, the threshold of significance was set at the 5% level with a P values <0.05.

Results

Table 1: The Demographic Characteristics of the Sample (N=100)

Demographic Characteristics	Study Group (n=50)		Control Group (n=50)	
	No	%	No	%
Age				
X ± SD	42.70 ±12.49		45.98 ± 15.05	
Gender				
Male	30	60.0%	28	56.0%
Female	20	40.0%	22	44.0%
ICU Diagnosis				
Respiratory failure	6	12.0%	10	20.0%
Intracranial hemorrhage	8	18.0%	6	*1*.0%
Subarachnoid hemorrhage	12	24.0%	9	18.0%
Post Arrest	4	8.0%	2	*4*.0%
Subdural hemorrhage	5	10.0%	5	10.0%
Hypovolemic Shock	2	4.0%	5	10.0%
Septic Shock	4	8.0%	6	12.0%
Chest trauma	4	8.0%	5	10.0%
Acute Respiratory Distress Syndrome	5	10.0%	2	2.0%

Table (1): illustrates that the mean age of the participants in the study and the control group was (42.70 ±12.49 and 45.98 ± 15.05) years old respectively. Regarding gender, more than half of the participants in both study and control groups were male (60.0% and 56.0%) respectively. Concerning ICU diagnosis, the highest percentage of the participants has subarachnoid hemorrhage (24.0%), but in the control group the highest percentage of the participants has respiratory failure (20.0%).

Table 2: The Effect of ABCDE Bundle on Hemodynamic and Oxygenation Parameters

Items	Study Group X ± SD	Control Group X ± SD	Independent t test	P -value
Mean Arterial Pressure				
Pre intervention	68.20 ± 8.33	65.20 ± 8.99	1.788	0.077
Post intervention	79.00 ± 5.21	71.50 ± 5.51	6.988	0.000
Paired t test	3.487	3.527		
P-value	0.00*1*	0.001		
Heart Rate				
Pre intervention	87.10 ± 30.19	95.10 ± 22.13	-1.511	0.134
Post intervention	73.40 ± 24.28	85.20 ± 11.39	-3.110	0.002
Paired t test	3.302	3.221		
P-value	0.001	0.002		
Central Venous Pressure				
Pre intervention	2.82± 1.17	2.54± 1.03	1.266	0.208
Post intervention	4.36 ± 1.10	2.70 ± 0.91	-3.527	0.001
Paired t test	3.050	1.281		
P-value	0.004	0.211		
Respiratory Rate				
Pre intervention	24.56 ± 9.30	22.30 ± 3.89	1.584	0.116
Post intervention	16.64 ± 1.32	18.26 ± 1.56	-3.487	0.001
Paired t test	2.821	1.471		
P-value	0.0*2*	0.103		
PH				
Pre intervention	7.38 ± 0.028	7.39 ± .029	-.877	0.383
Post intervention	7.37 ± 0.027	7.38 ± .023	-1.239	0.218
Paired t test	-1.281	-1.281		
p-value	0.211	0.211		
$PaCO_2$				
Pre intervention	39.46 ± 4.01	38.66 ± 3.70	1.269	0.207
Post intervention	37.1 ± 3.41	37.66 ±3.53	-0.718-	0.474
Paired t test	-2.821	-1.471		
p-value	0.0*2*	0.103		
PaO_2				
Pre intervention	81.90 ± 2.69	83.32 ± 5.51	1.635	.105
Post intervention	91.22 ± 3.54	87.50 ± 4.29	-3.302	.001
Paired t test	-3.110	-2.730		

p-value	0.002	0.001		
S_aO_2				
Pre intervention	91.06 ± 3.35	92.02 ± 5.37	-1.043	0.299
Post intervention	96.36 ± 1.38	95.20 ± 1.79	-2.732	0.007
Paired t test	-3.302	-3.221		
p-value	0.001	0.002		

Table (2) shows that there was a statistically significant difference in the mean score of the hemodynamic parameters (MAP, HR, and CVP). Also there was a statistically significant improvement in the oxygenation parameters (RR, PH, PaO_2 and S_aO_2) in the study group compared with the control group post intervention.

Table 3: The Effect of ABCDE Bundle on Ventilator Free Days and ICU Length of Stay

Items	Study Group X ± SD	Control Group X ± SD	Independent t test	P -value
Ventilator Free Days				
X ± SD	6.10 ± 1.77	4.70 ± 1.53	3.255	0.002
ICU Length of Stay				
X ± SD	10.00 ± 2.67	14.70 ± 3.72	3.527	0.001

NB: $^{(HS)}$ = (p<0.001)

Table (3) indicates that there was a highly statistical significant decrease in the mean score of ventilator free days of the study group (6.10 ± 1.77) compared with the control group (4.70 ± 1.53) (P< 0.002). Also, there was a highly statistically significant difference in the mean ICU length of stay in the study group (10.00 ± 2.67) compared with the control group (14.70 ± 3.72) post intervention (P< 0 .001) which indicate that the implementation of the ABCDE bundle deceased the duration of mechanical ventilation four days for participants in the study group.

Table 4: Average Dose of Sedative Medications Prescribed

Items	Study Group X ± SD	Control Group X ± SD	T test	P -value
Sedative (Midazolam)	117.50 ± 42.93	142.00 ±35.87	-3.097-$^{(S)}$	0.003

$^{(HS)}$ = (p<0.001)
$^{(S)}$ = (p<0.05)

Table (4) shows that there was a statistically significant reduction in the amount of prescribed Midazolam to the study group compared with the control group (117.50 ± 42.93) (142.00 ±35.87) respectively P<0.003.

Discussion

The effect of ABCDE bundle on oxygenation and hemodynamic status.

Sedation and analgesia treatment has a non-selective inhibition on the circulatory and respiratory center [26]. Thus, monitoring the hemodynamic parameters is an important clinical strategy for mechanically ventilated patients, which can guide therapy and improve tissue perfusion.

The current study hypothesized that the patients who received ABCDE bundle intervention are more likely to have improved oxygenation and hemodynamic parameters than the patients who do not receive the ABCDE Bundle intervention. The present study findings supported the first research hypothesis and revealed that there was a statistically significant improvement in the mean score of the hemodynamic parameters including MAP, HR and the CVP. Also, there was a statistically significant improvement in the PaO_2 and the respiratory rate.

similar findings were reported by [15] who investigated the effect of the ABCDE bundle on hemodynamic in mechanically ventilated patients and found that there was a statistically significant increase in the mean score of MAP, oxygenation index (PaO_2/FiO_2) and decrease in the heart rate in the study group post intervention.

The Effect of ABCDE Bundle on Duration of Mechanical Ventilation and ICU length of stay.

The implementation of the ABCDE bundle resulted in significant improvements in patient outcomes including ICU length of stay (LOS), free days of MV, mortality, early mobility, and hemodynamic stability. The current study hypothesized that patients who receive ABCDE Bundle intervention are more likely to experience less duration of mechanical ventilation and ICU length of stay than patients who do not receive the ABCDE Bundle intervention.

The present study findings supported the second research hypothesis and revealed that there was a highly statistically significant increase in the mean score of ventilator free days and less ICU length of stay in the study group post intervention compared with the control group. These findings are concurrent with [27] who found that critically ill patients managed with the ABCDE bundle have more ventilator free days compared with patients treated with the usual care. Similar findings were reported by [15] who investigated the effects of ABCDE bundle on related prognostic indicators including duration of mechanical ventilation and ICU length of stay among mechanically ventilated patients and reported that the study group had statistically significant decreased ICU length of stay than the control group who did not receive the ABCDE bundle intervention.

However, the findings of the current study are different from what was reported by [28] who did not find significant difference in ventilator free days post intervention between the study and the control group. Furthermore [29], found that there was no statistically significant difference in the number of MV free days, ICU length of stay after the implementation of the ABCDE bundle.

The Effect of ABCDE Bundle on the amount of Prescribed Sedatives Medications.

The finding of the present study revealed that there was a statistically significant reduction in the amount of prescribed sedative to the study group compared with the control

group. The findings of the current study are similar to the findings of [15] who reported that there was a statistically significant decrease in the sedative amount administered in the group who received the ABCDEC bundle intervention compared with the control group.

However, the findings of the current study are different from what was reported by [28] who found that the total average daily doses of sedatives administered did not change significantly in both study and control group post ABCDE bundle implementation.

Limitations of the Study

The main study limitation of the current study is that this was not a randomized study design. Lack of randomization limits the generalization of the study findings.

Conclusion

ABCDEF bundle practice resulted in significant improvements in clinical outcomes including oxygenation and hemodynamic status; increasing ventilator free days and decreasing ICU length of stay. Additionally, Implementation of ABCDE reduced the dose of the sedatives and analgesics medications used.

Recommendations

Continuous training for critical care nurses to practice ABCDE bundle as a routine care of mechanically ventilated patients.

Implications for Future Research

Well designed randomized clinical trials with more heterogeneous sample are needed to examine the effects of all the ABCDE bundle components. Inclusion of multiple ICU types (medical, surgical, neurological, trauma) will help to understand the effect of the ABCDE bundle as a whole on a variety of types of critically ill patients. Also, it will expand our understanding of implementation strategies that are distinctive to these populations in each setting.

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