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Effectiveness of Care Bundle on Hemodynamic, Oxygenation, level of Consciousness and Pupil Reactivity among Traumatic Brain Injury Patients

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Abstract
Background: Care Bundle is an effective way in minimizing morbidity and mortality among critically ill patients with traumatic brain injury by enhancing hemodynamics, improving oxygenation, level of consciousness and pupil reactivity. **Purpose of the study:** to examine the effectiveness of care bundle on hemodynamic, oxygenation, level of consciousness and pupil reactivity among traumatic brain injury patients. **Setting:** Current research was conducted at Trauma ICU, Menoufia University Hospital, Egypt. **Sample:** A convenient sample of 60 patients admitted to Trauma ICU. **Design:** A Quasi-experimental design was used (study and control). **Instruments:** 1) Demographic and Medical Data Sheet; 2) Hemodynamic Parameters Measurements; 3) Oxygenation Parameters Measurements; 4) Glasgow Coma Scale (GCS) and 5) Pupil Reactivity and Pupil Size Assessment Scale. **Results:** There was a statistically improvement in hemodynamic parameters in the study group compared to the control group post intervention ($p < 0.001$). There was a statistically significant improvement in the oxygenation (paO_2, saO_2) of the study group who received care bundle intervention compared to the control group post intervention ($p <0.001$). Additionally, the level of consciousness was statistically higher in the study group (8.66± 0.85) than the control group (5.57± 1.48) ($p<0.001$). Pupil reactivity also, exhibited a highly statistically significant difference between study and control groups post intervention ($P = 0.001$). **Conclusion:** Implementation of a care bundle demonstrated enhanced hemodynamic parameters, improved oxygenation, elevated level of consciousness, and enhanced pupil reactivity in traumatic brain injury patients. **Recommendation:** Integration of care bundle into clinical practice setting will improve clinical outcomes for TBI patients in the Trauma ICU.

Keywords: ***Care Bundle, Hemodynamic, level of Consciousness, Oxygenation, Pupil Reactivity & Traumatic Brain Injury.***

Introduction
Traumatic Brain Injury (TBI) is a serious form of trauma, significantly contributing to global morbidity and mortality, particularly among young adults **(Beshay et al., 2022)**. In the United States, 2.8 million people suffer traumatic brain injuries each year. About 282,000 of these cases result in hospital admission, and 56,000 of them expected to die. Patients with TBI account for 6% to 8% of all cases that are recorded; the main causes of TBI are falls (47%), blunt injuries (15%), unknown or other causes (15%), auto accidents (14%) and assaults (9%) **(Moradiya, & Geocadin, 2022)**.

In Egypt, according to Global Burden of Diseases **(GBD, 2019)**, Traffic accidents are the primary cause of TBI in young males, with severe injuries occurring in 20.3% of cases. Also, there were 262,264 new TBI cases and 484, 935 cases were living with TBI-related disabilities. The prevalence of function disabilities linked to TBI increased by 23.2%; with 52% more experienced arousal impairment. Approximately 39.7% of traumatic head injury admitted at neurosurgery ICU (548 out of 1382) were representing with blunt head trauma being the most common type of trauma 57.3%, followed by 43.7% multiple trauma.

The Centers for Disease Control and Prevention **(CDC, 2021)** was described traumatic brain injury as "a disturbance of the brain activity resulting from an impact, blow or a penetrating head injury". This can lead to lasting impairment in cognitive, physical, or emotional capabilities, persisting for years or even a lifelong. TBI induces two distinct phases of brain damage with primary brain injury occurs at the time of trauma, and secondary brain injury, resulting unchangeable consequences.

Patients with traumatic brain injury are highly susceptible to secondary head injuries due to concurrent multisystem problems, including pulmonary pathology, cerebrovascular damage, acute mechanical ventilation dependency, fluid and electrolyte imbalances, and cardiovascular susceptibility **(Al Saiegh et al., 2021)**. Secondary brain injury usually begins within hours or days and is caused by brain herniation, hypoxia, and increased intracranial pressure (ICP) or systemic hypotension.

These variables have a substantial impact prognosis of patients, highlighting the significance of managing traumatic brain injury with an emphasis on reducing secondary brain damage **(Moradiya, & Geocadin, 2022)**.

Cerebral ischemia and secondary brain injury result from hemodynamic alterations that follow a primary brain injury. A multitude of secondary brain injuries, encompassing intracranial as well as extra cranial or systemic, have the potential to exacerbate the primary brain injury and lead to secondary brain injury **(Algethamy, 2020)**. Systemic insults primarily manifest as ischemic event, causing hemodynamic alteration as hypotension or hypertension; hypoxemia, acid-base imbalances, hypercapnia and changes in body temperature including fever or hypothermia **(Beshay et al., 2022)**. Early episodes of hypotension and hypoxia have been shown to dramatically increase morbidity and death rates in TBI patients **(Okidi et al., 2021).** So maintaining an adequate oxygenation and cerebral blood flow is crucial in the management of TBI **(Pélieu et al., 2019).** Monitoring hemodynamic and arterial blood oxygenation serves as an early indicator of adequate cerebral oxygenation in TBI **(Okidi et al., 2021).**

The level of consciousness plays a crucial role in predicting neurological prognosis and survival for patients with TBI. Prolonged period of unconsciousness such as being in a coma tend to correlate with slower recovery rates, potentially extending the duration of intensive care unit stays **(Algethamy, 2020).** Traumatic Brain Injury patient exhibiting altered conscious level has been associated with higher fatality rate. Disturbances in consciousness represented a neurological disorder that render patient unaware of their surroundings and unresponsive to external stimuli **(Al Saiegh et al., 2021).**

Pupil reactivity in patient with TBI is frequently associated with neurological deterioration, leading to poor clinical outcomes **(Niimi et al., 2021).** The presence of acute pupillary abnormalities often indicates mechanical compression on cranial nerve III, resulting in compromised brain stem function and damage to the sphincter pupillae muscle. This damage can increase ICP due to progression of hematoma, hemorrhage or cerebral edema. Trauma nurses should remain aware for additional clinical factors that might contribute to abnormal pupil response **(Joseph& Paul, 2021).** Trauma nurses play a crucial role in the care of TBI- affected patients and have the potential to influence their recovery course, it is imperative for nurses to have access to evidence-based resources to enhance positive patient outcomes **(Zrelak et al., 2020).**

TBI patients require immediate care and ongoing monitoring in order to prevent neuronal cell death, preserve adequate brain perfusion, and reduce the chance of permanent impairment **(Iaccarino et al., 2021).** Delayed, inaccurate, or inappropriate treatment has been associated with increased patient death and poorer long-term disability. Even while appropriate and consistent care can enhance patient outcomes and lower total health care costs **(Li et al., 2021).**

Incorporating care bundles into emergency care has shown positive effects on patients' outcomes **(Li et al., 2021).**The Institute for Healthcare Improvement **(2022)** characterizes a care bundle as "a structured approach to enhance care processes and patient outcomes, typically comprising three to five evidence based practices that when consistently implemented, have demonstrated effectiveness. The TBI care bundle, which was created via a primary survey approach, includes evidence-based procedures for cervical spine immobilization, airway securement, oxygenation and ventilation control, fluid resuscitation, circulation, and ICP control. Several clinical studies revealed that adherence to the care bundle in the Trauma ICU is significantly associated with reduced mortality rate in TBI patients and improved overall outcomes **(Al Saiegh et al., 2021).**

Significance of the Study

Road Traffic Accidents (RTAs) being the primary cause of traumatic brain injury in Egypt, as reported by Central Agency for Public Mobilization and Statistics **(CAPMAS, 2020).** To enhance outcomes, comprehensive healthcare approach through the entire chain of the brain trauma management, including emergency care, is essential **(Pélieu et al., 2019).**

In the early stages of neuroprotective nursing care for patients with moderate to severe traumatic brain injury (TBI), nurses play a critical role in monitoring oxygenation and ventilation, measuring intracranial pressure (ICP), measuring cerebral perfusion pressure (CPP), and performing neurological examinations. The effective execution of these duties by the nurses significantly affects patient mortality and outcomes. Therefore, providing nurses with a valuable resource incorporating evidence-based nursing practices is essential for achieving the best possible outcomes **(Promlek et al., 2020).**

Evidence suggests that implementing various care bundles in the Emergency Department (ED) enhances clinical outcomes, lowers the death rate, and facilitates patient care **(Ladbrook et al., 2021).** Despite the increasing support for the positive impact of care bundles, there are few studies that examined the effectiveness of care bundle on traumatic brain injury patient's outcomes. Thus, the present study aimed to evaluate the effectiveness of care bundle on hemodynamic, oxygenation, level of consciousness and pupil reactivity among traumatic brain injury patients. Findings generated from the current study will enable critical care nurses in assisting TBI patients to enhance their hemodynamic, oxygenation, level of consciousness and pupil reactivity.

Purpose of the Study

To examine the effectiveness of care bundle on hemodynamic, oxygenation, level of consciousness and pupil reactivity among traumatic brain injury patients.

Operational Definitions

Hemodynamic Parameters: In the present study, hemodynamic parameters are operationally defined as the obtained individual's reading measurement of (systolic BP, diastolic BP, and heart rate, RR, MAP and CVP).

Oxygenation:

In the present study, oxygenation is operationally defined as the obtained individual's results of ABG.

Level of Consciousness:

In the present study, level of consciousness is operationally defined as the individual obtained score of the Glasgow Coma Scale.

Pupil Reactivity:

In the present study, pupil reactivity is operationally defined as the individual obtained score of Pupil Reactivity and Pupil Size Assessment Scale.

ICU Length of Stay:

In the present study ICU length of stay is operationally defined as the number of days patient spends in the ICU from the day of ICU admission to the day of discharge from the ICU.

Care Bundle for Traumatic Brain Injury:

In the present study, Care bundle is operationally defined as group of interventions performed together which includes establishing a secure airway along with c-spine protection, maintaining adequacy of oxygenation and ventilation, maintaining circulation and fluid balance, assessing the GCS, pupil size, and pupil reactivity to light, maintaining cerebral venous outflow through patient positioning, managing the patient’s pain, agitation, and irritability and preparing the patients for an urgent CT scan. The study group was received the care bundle once they were admitted to the emergency department.

Research Hypotheses

1) Patients who receive care bundles are expected to have better hemodynamic parameters than the control group who receive routine hospital care.
2) Patients who receive care bundles are expected to have better oxygenation parameters than the control group who receive routine hospital care.
3) Patients who receive care bundles are expected to have improvement in the level of consciousness than the control group who don't receive the intervention.
4) Patients who receive the care bundle will have better pupil reactivity compared with the control group who don't receive the intervention.
5) Patients who receive the care bundle intervention have shorter ICU stay than the control group who don't receive the intervention.

Methods

Research Design:

A quasi experimental design (study / control) was utilized to test the study hypotheses

Setting: The current study was conducted at emergency department and Trauma ICU at Menoufia University Hospital ,Shebin EL-Kom, Egypt.

Sample:

A purposive sample of 60 adult trauma patients recruited from emergency department and Trauma ICU at Menoufia University Hospital ,Shebin EL-Kom. Patients were approached to participate in the study if they met the inclusion criteria, which include: a) aged 18 to 65years old with a GCS <12; b) arrived to the emergency department within the first two hours after trauma. Patients were excluded if they have experienced; a) cardiovascular or metabolic disorders, significant chest or abdominal trauma, multiple fractures because those patients cannot respond to the designed intervention; b) a history of brain disorders (tumors or old cerebral stroke) because their brain function may be affected as a result of prolonged hypoxia. The participants were randomly divided into two equal groups; 30 patients each. The experimental group who received care bundle and the control group who received a routine hospital care.

Sample Size Calculation:

G Power Software was used to calculate the sample size. To detect a difference in group proportions of 0.3100, an 85% power is achieved with a sample size of 25 patients per group. The two-sided Z test with pooled variance and a significance level of 0.0164 was the statistical test that was employed. The medium effect size and a 0.05 were used to calculate the sample size. Another 10 patients were added to compensate for the attrition rate in those patients, which reported at 9% **(Richter et al., 2020).** So, sixty patients made up the final sample size (30 patient for each group).

Instruments for Data Collection:

Demographic and Medical Data Sheet:

It includes data about patient's age, sex, and diagnosis, mechanism of injury and severity of injury. Data were taken from of the patient's medical file.

Hemodynamic Parameters Measurements:
It developed by the researcher to gather information on a range of hemodynamic measurements, such as Central Venous Pressure (CVP), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP) and Hart Rate (HR).The automatically calibrated Nihon Kohden Life Scope Bsm-3500 monitor was used to collect the data. The Cronbach's Coefficient Alpha (a=.0.87) was used to evaluate the dependability of the bedside monitor (NIHON KOHDEN, life scope, BSM 3000 series). A study by **Helfand et al., (2011**) proved its validity by showing that among ICU patients, the accuracy of the heart rate was 94.4% and the accuracy of the respiratory rate was 93.1%.

Oxygenation Parameters Measurements:
The RAPID Point 500 Blood Gas Analyzer was developed by **Severinghaus, (2002)**, which had a completely automated calibration system that needed to be recalibrated every two hours, was used to record the values of arterial blood gases (SaO2, PaO2, and PaCo2). With intra- and inter-assay coefficients greater than 0.91, the Rapid Point 500(®) was found to be reliable in a sample of 165 adult intensive care unit patients **(Nicolas et al., 2013)**. Using paired-sample measurements on 114 randomly chosen patient blood samples, the validity of the Rapid Point 500(®) was assessed in comparison to a reference analyzer. Furthermore, a 20-day study employing standard reference material revealed noteworthy correlation values ($r = 0.962$ for pH, $r = 0.9955$ for PaCO2, and $r = 0.9829$ for PaO2), confirming the Rapid Point 500(®)'s sufficient accuracy and precision in clinical application. **(MacIntyre et al., 2006).**

Glasgow Coma Scale (GCS):
It developed by **Teasdale & Jennett, (1974)**, serves as a neurological scale providing a reliable and objective method to evaluate the conscious level of TBI patients during initial and subsequent evaluation. A patient is assessed against specific criteria including visual, verbal and motor responses with assigned points yielding an overall score. A maximum score of 15 indicates full alertness, while a minimum score of 3 signifies complete unresponsiveness. A score of 8 or below denotes low consciousness, 9–12 indicates moderate consciousness, and 13–15 indicates high consciousness. Verbal reply scores vary from 1 (no response at all) to 5 (orientation), motor response scores from 1 (no response at all) to 6 (obeying orders), and ocular response scores from 1 (no opening) to 4 (spontaneous opening).
According to **Gujjar et al., (2013)** there was evidence of a high level of validity for the GCS scale in TBI patients ($r^2=0.233$, $p<0.0001$). Additionally, 50 adult TBI patients participated in a study that verified the reliability of GCS. The overall scale's internal consistency, measured using Crombach Coefficient alpha, was 0.81 **(Gujjar et al., 2013).**

Pupil Reactivity and Pupil Size Assessment Scale:
It is non-invasive, reliable and objective measurement used to assess pupil size, symmetry and reactivity by using pupillometer device. The device stimulates pupil constriction with a gentle flash of light as the infrared camera capture several image. Pupil reactivity assessment scale enhance objectivity in measurements by comparing the patient's pupillary light reflex to normal data categorizing responses as normal (brisk ,>3.0), abnormal (sluggish, <3.0) or atypical (immeasurable or non-reactive (0). Pupil size is quantified in millimeters within normal range of the 2 and 5 mm and it is assessed for round, irregular, or oval shape. In a study involving two hundred adult ICU patients, the reliability of the pupillometer showed high intra- and inter-assay coefficients exceeding 0.98 **(Jahns et al., 2019).**

Ethical Consideration:
Approval for the study was granted by the Ethical and Research Committee at the faculty of nursing, with an assigned approval number (981). The researcher also secured official permission from hospital director to conduct the research after explaining the study's purpose. Relatives of participants provided written consent before participating and during the initial interview, they were briefed on the study's purpose, procedure, and potential benefits. The researcher explained to the relatives that participation in the study is voluntary and that they could leave the study at any time without it having an impact on their care. To maintain confidentiality and anonymity all data were coded and collecting data sheets were securely stored in a closed cabinet.

Pilot Study:
Involving 10% of the study sample (Six patients), was undertaken to assess the feasibility and relevance of the questionnaire. The aim was to identify potential issue during data collection and determine the time required to complete the questionnaire. The participants in the pilot study were excluded from the final analysis.

Data Collection Procedure
An official permission was obtained by the researcher from hospital director to carry out study after explaining its purpose.
Assessment phase:
- The subjects who met the study inclusion criteria were divided into two groups (30 patient each). The participants were recruited to participate in the

study when admission to emergency department, at Menoufia University Hospital.
- The researcher started with the control group (II) first then the study group (I) to avoid contamination of results.

Planning phase:
- The researcher divided the sample into two groups. study group and control group
- Participants were assigned randomly to either study or control group. Experimental group received the care bundle intervention and the control group received the usual standard hospital care, involving activities such as connecting patients to a bedside monitor, endotracheal intubation if necessary, providing intravenous fluids, and conducting CT scans.
- The researcher initially gathered demographic and medical data during first encounter using instrument (I). Subsequent assessments, including the haemodynamic parameters (instrument II), oxygenation (Instrument III), conscious level (instrument IV), pupil reactivity (instrument V), were measured at baseline and one week post intervention.

Implementation phase

The care bundle intervention for the study group involved comprehensive strategies for traumatic brain injury (TBI) patients upon admission to the emergency department. Adopted from the Institute for Healthcare Improvement (2022), the bundle encompassed the following:
- Ensuring a secure airway and c-spine protection: Utilizing the jaw thrust maneuver, nursing management during endotracheal intubation (manual inline stabilization), confirming correct endotracheal tube placement, and applying a cervical collar.
- Maintaining oxygenation and ventilation: Administering supplemental oxygen to achieve target saturation levels, employing non-invasive ventilation methods, continuous monitoring of oxygen saturation, respiratory rate, and arterial blood gases.
- Sustaining circulation and fluid balance: Administering intravenous fluids, continuously monitoring blood pressure, heart rate, Central Venous Pressure (CVP), and Mean Arterial Pressure (MAP) using a bedside monitor.
- Evaluating level of consciousness using the GCS: Assessing eye opening, verbal response, and motor response. Evaluating pupil reactivity, noting size and asymmetry, measuring size with a penlight, and observing responses to light.
- Maintaining cerebral venous outflow through patient positioning: Elevating the head of the bed to 30 degrees and avoiding extreme head positions.
- Managing agitation, pain, and irritability: applying urinary catheterization, splinting fractures, taking analgesics, and keeping an eye out for agitation symptoms.
- Preparing for urgent CT or MRI: Assessing the extent and location of brain injuries and ruling out surgical lesions requiring immediate intervention. Implementation of the care bundle ranged from 45 to 120 minutes per patient.

Evaluation phase:
- Measurements of hemodynamic parameters, oxygenation, level of consciousness, and pupil reactivity were taken before the intervention and one week post-intervention to assess the impact of the care bundle on these aspects among traumatic brain injury patients.
- A comparison was made between both groups (study and control groups) to examine the effect of Effectiveness of Care Bundle on Hemodynamic, Oxygenation, level of Consciousness and Pupil Reactivity among Traumatic Brain Injury Patients

Data Analysis

Data will be statistically analyzed using Statistical Package for Social Science (SPSS) Version 26 for Windows. Data will be presented as frequency and percentage. Student t-test will be used to compare between two means. Level of significance will be set as P value <0.05. Paired t –test will be used to detect the mean and standard deviation of normally distributed values.

Results

Characteristics of the Sample:

Sixty adult patients who attended the emergency department and Trauma ICU at Menoufia University Hospital, Shebin EL-Kom, and Menoufia Governrat were approached over a five- month period from the beginning of June 2023 to the end of October 2023.

Table (1): Demographic and Medical Data of the Studied Groups (N= 60)

Demographic and Medical Data	Study Group (n=30)		Control Group (n=30)		P -value
Age					
Mean ±SD	35.26±11.98		34.28±12.92		0.372 ns
Sex	**No**	**%**	**No**	**%**	
- Male	24	80.0	27	90.0	
- Female	6	20.0	3	10.0	0.352 ns
Mechanism of Injury					
- Road traffic accidents	22	73.3	24	80.0	0. 404 ns
- Falls	5	16.7	4	13.3	
- Bunt Trauma	3	10.0	2	6.7	
Severity of Injury					
- Mild	2	6.7	3	10.0	0.625 ns
- Moderate	6	20.0	6	20.0	
- Sever	22	73.3	21	70.0	

Note: *P-value of chi square*
t: *Independent t-test*
(ns): *not significant (p value>0.05)*

Table (2): The Effect of Care Bundle on Hemodynamic Parameters among Studied Group Post Intervention (N= 60)

Hemodynamic Parameters	Studied groups		Student's t test	P value	ANOVA Test of study group P value
	Study group (n=30)	Control group (n=30)			
	Mean±SD	Mean±SD			
Heart rate:					
- On admission	86.23± 7.56	82.60± 6.95	t*1.40	0. 26 NS	7.18 P 0.003 S
- Post intervention	89.17± 7.10	70.0± 7.46	t*1.68	0.001 S	
Systolic BP:					
- On admission	122.17± 7.46	123.13± 7.98	t*0.48	0.63 NS	4.33 0.01 S
- Post intervention	122.43± 7.49	144.33± 9.51	t*0.85	0.01 S	
MAP:					
- On admission	75.67± 6.05	77.03± 8.66	t*5.25	<0.21 NS	11.53 P 0.001 HS
- Post intervention	89.01± 5.71	71.87± 8.56	t*3.02	0.004 S	
CVP:					
- On admission	5.70± 1.17	5.40 ± 1.35	t*0.91	0.36 NS	1.62 P 0.001 HS
- Post intervention	9.83± 1.08	5.02 ± 1.45	t*1.05	0.01 NS	

Note: t*: *Independent t-test*
(S): *Significant (p value<0.05)*
(HS): *High significant (p<0.001)*

Table (3): The Effect of Care Bundle on Oxygenation Parameters among Studied Group Post Intervention (N= 60)

Oxygenation Parameters	Studied groups		Student's t test	P value	ANOVA Test of study group P value
	Study group (n=30)	Control group (n=30)			
	Mean±SD	Mean±SD			
Respiratory Rate					9.75
- On admission	21.10± 1.49	20.0± 1.60	t*0.24	0.23 NS	P <0.001 HS
- Post intervention	17.77± 2.23	22.53± 4.36	t*2.65	0.01 S	
PH:					25.59
- On admission	7.48± 0.03	7.49± 0.05	t*5.20	0.36 NS	P <0.001 HS
- Post intervention	7.38± 0.03	7.50± 0.06	t*6.43	<0.001 HS	
PaO_2:					6.39
- On admission	85.90±10.82	75.33± 11.02	t*4.54	0.26 NS	P 0.002 S
- Post intervention	92.55± 12.50	71.66±11.27	t*5.03	<0.001 HS	
SaO_2:					5.29
- On admission	95.43± 4.28	91.40± 4.23	t*6.45	0.21 NS	P 0.005 S
- Post intervention	99.43± 1.89	86.65± 1.82	t*8.01	<0.001 HS	
Paco2:					22.81
- On admission	44.09± 1.43	46.35± 6.05	t*4.44	0.33 NS	P <0.001 HS
- Post intervention	40.57± 2.34	49.83±6.46	t*4.85	<0.001 HS	

Note: *(S): significant (p value<0.05),* ***(HS):*** *High significant (p<0.001),* ***t*:*** *Independent t-test*

Table (4): The Effect of Care Bundle on Level of Consciousness among Studied Group Post Intervention (N= 60)

GCS	Study Group (n=30) Mean ±SD	Control Group (n=30) Mean ±SD	Student's t test	P value
- On admission	4.79± 1.98	4.82± 1.90	2.59	0.001 HS
- Post intervention	8.66± 0.85	5.57± 1.48		

Note: *t: Independent t-test,* ***(HS):*** *High significant (p<0.001)*

Table (5): The Effect of Care Bundle on Pupil Reactivity among Studied Group Post Intervention (N= 60)

Cerebral Oxygenation	Studied groups				Student's t test	P value	ANOVA Test of study group P value
	Study group (n=30)		Control group (n=30)				
	No	%	No	%			
Pupil size:							
- Normal pupils	16	53.3	10	33.3			36.49
- Dilated pupils	14	46.7	20	66.7	6.28	0.001 HS	P <0.001 HS
Pupil reactivity							
- Both	24	80.0	9	30.0			4.29
- One	2	10.0	12	40.0	4.45	0.001 HS	P <0.001 HS
- None	2	10.0	9	30.0			

Note: P-value of chi square, t: Independent t-test, (HS): High significant (p<0.001)

Table (6): The Effect of Care Bundle on ICU Length of Stay among Studied Group Post Intervention (N= 60)

Variable	Study Group (n=30) Mean ±SD	Control Group (n=30) Mean ±SD	Student's t test	P value
ICU Length of Stay	5.07 ± 2.22	11.75 ± 2.83	t*6.59	P <0.001 HS
Hospital Length of Stay	14.81 ± 3.57	19.21 ±3.36	t*5.28	P <0.001 HS

Note: t*: *Independent t-test,* ***(HS):*** *High significant (p<0.001)*

Table (1): Shows that the mean age of the participants in both the study and control groups is 35.26±11.98 and 34.28±12.92, respectively. The majority of participants in the study group (80%) and the control group (90%) are male. Road traffic accidents were the primary causes of injury for both groups, accounting for 73.3% in the study group and 80% in the control group. Moreover, severe TBI was observed in 73.3% of the study group and 70% of the control group. No statistically significant differences were found between both groups regarding to their demographic and medical data.

Table (2): Reveals a statistically significant improvement in all hemodynamic parameters in the study group compared to the control group after intervention. There was a statistically significant improvement in heart rate (HR), mean arterial pressure (MAP) and central venous pressure (CVP) in the study group (89.17± 7.10; 89.01± 5.71; 9.83± 1.08) compared to the control group (70.0± 7.46; 71.87± 8.56; 5.02± 1.45) after intervention ($p < 0.001$).

Table (3): Demonstrates a statistically significant improvement in oxygenation parameters, as indicated by the improvement of ABG results in the study group compared to the control group post-intervention. The study group exhibited a statistically significant increase in partial pressure of oxygen (PaO_2) (92.55±12.50) compared to the control group (71.66±11.27) after intervention ($P < 0.001$). Additionally, there was a statistically significant increase in oxygen saturation (SaO_2) in the study group (99.43±1.89) compared to the control group (86.65±1.82) post-intervention ($P < 0.001$).

Table (4): Shows that there was a highly statistically significant improvement in level of consciousness in the study group (8.66± 0.85) compared to (5.57± 1.48) in the control group after intervention, respectively ($P = 0.001$).

Table (5): Shows a significant improvement in pupil reactivity in the study group compared to the control group after intervention ($P = 0.001$). In the study group, 46.7% of patients exhibited dilated pupils, compared to 66.7% in the control group post-intervention. The majority of patients in the study group (80%) represented reactive pupils in both eyes, compared to 30% in the control group after intervention ($P < 0.001$).

Table (6): Illustrates that the mean ICU length of stay in the study group was significantly reduced (5.07 ± 2.22) days compared to the control group (11.75 ± 2.83) days after the intervention ($p<0.001$). Additionally, the mean hospital length of stay in the study group was significantly decreased (19.21 ± 3.36 days) compared to the control group (14.81 ± 3.57) days after the intervention ($p<0.001$).

Discussion

Traumatic brain injury care bundles consist of evidence-based practices designed to enhance patient care, improve clinical outcomes, reduce mortality rates, and mitigate long-term complications **(Al Saiegh et al., 2021).** Utilizing these care bundles serves as a way to overwhelm the gap between clinical practice and research **(James et al., 2019).** The implementation of care bundles has been shown to improve clinical outcomes, including hemodynamic parameters, oxygenation, conscious level, and pupil reactivity, while also contributing to a reduction in the ICU length of stay **(Al Saiegh et al., 2021).**

Effect of Care Bundle on Hemodynamic Parameters:

The impact of the care bundle on hemodynamic parameters suggests a potential enhancement in maintaining consistent cerebral blood flow, leading to a substantial reduction in morbidity and mortality among patients with TBI. This research tested the hypothesis that patients who receive care bundles are expected to have better hemodynamic parameters than the control group who receive routine hospital care. This hypothesis was supported by the findings of the present study, which showed a statistically significant improvement in heart rate (HR), mean arterial pressure (MAP) and central venous pressure (CVP) in the experimental group after intervention compared to the control groups. These results align with previous studies by **Paul et al., (2022) & Kersting et al., (2020)** which similarly observed a significant improvement in hemodynamic measures in TBI patients receiving evidence-based care bundles compared to those receiving routine care.

Also, this result is in line with the study conducted by **Rubiano et al., (2020)** who examined the effect of a care bundle on hemodynamic status in traumatic brain injury patients and found a significant improvement in HR, MAP, and CVP in the care bundle group compared to the control group. **Collinsworth et al., (2020)** also observed a statistically significant improvement in HR, MAP, and CVP in the study group following care bundle intervention compared to the control group. These findings are consistent with **Beshay et al., (2020)** who reported a statistically significant improvement in hemodynamic parameters, including HR, MAP, and CVP, after care bundle intervention compared to routine care.

However, the current study's findings differ from those of **Steiner et al., (2016)** who found that care bundle interventions did not significantly improve HR, MAP, and CVP. A possible explanation of Steiner's results may be attributed to the specific nature of the illness and the prevalence of hypovolemia secondary to hemorrhage or excessive bleeding during trauma within Steiner's sample. The hemodynamic changes associated with traumatic brain injury may be influenced by hypovolemia, leading to decreased perfusion to vital organs, reduced venous return, lower SBP causing hypotension, and diminished measurements of MAP and CVP.

Effect of Care Bundle on Oxygenation Parameters

Care bundles optimizing lung volumes, flow rates, and capacities, leading to increased spontaneous tidal volumes and enhanced respiratory system compliance, resulting in improved oxygenation and decreased $PaCO_2$.This study's findings revealed a statistically significant increase in PaO_2 and SaO_2 in the experimental group receiving the care bundle compared to the control group with routine care after intervention. The study's findings supported the hypothesis of the present study. **Chesnut et al., (2020)** found a statistically significant increase in PaO_2 and SaO_2 in the care bundle group compared to the control group. This result is consistent with **Khan & Khan (2020)**, who found that care bundle intervention was superior to routine care in improving oxygenation. Furthermore, the present research's findings are consistent with those of **Ali et al., (2023)** who revealed a significant increase in PaO_2 and SaO_2 with care bundle intervention for TBI patients compared to the control group.

Effect of Care Bundle on Level of Consciousness

The initial Glasgow Coma Scale (GCS) holds significant predictive value for neurological prognosis and survival in traumatic brain injury patients, with a higher fatality rate observed in those with a lower level of consciousness on admission **(Algethamy, 2020; Al Saiegh et al., 2021).** The current study hypothesized that patients who receive care bundles are expected to have improvements in their level of consciousness compared with the control group who don't receive the intervention. The results of the present study demonstrated a statistically significant improvement in level of consciousness in the experimental group after intervention compared to the control group. These findings align with those of **Iaccarino et al., (2021)** who evaluated evidence-based care bundles on level of consciousness in TBI patients, noting a significant improvement in the research group compared to the control group. The improved level of consciousness in the bundle group may be attributed to the incorporation of the care bundle into patient care, as suggested by **Chesnut et al., (2020) & Godoy et al., (2020)** both reporting improved levels of consciousness after care bundles application.

However, **Steiner et al., (2016)** found no statistically significant difference in level of consciousness between the care bundle group and the control group in TBI patients. The explanation for this finding may be attributed to the fact that the majority of the sample had a Glasgow Coma Scale (GCS) score less than 7, potentially impairing patients' visual, verbal, and motor responses and consequently impacting their level of consciousness, which resulted in diminishing the effectiveness of the care bundle intervention.

Effect of Care Bundle on Pupil Reactivity

Pupil reactivity is another significant predictor of TBI patient outcomes **(Beshay et al., 2020).** Care bundle interventions play a vital role in enhancing pupil reactivity for TBI patients **(Lussier et al., 2019; Jahns et al., 2019).** This study hypothesized that patients who receive the care bundle will have better pupil reactivity compared with the control group who don't receive the intervention. The current study's results supported the hypothesis and showed that, after the intervention, the pupil reactivity of study group participants had significant improvement compared to the control group. Similar finding was reported by **Niimi et al., (2020), Khan and Khan (2020), & Okidi et al., (2020)** who similarly observed a statistically significant improvement in pupil reactivity in the study group compared to routine care. Additionally, the current research findings are consistent with those of **Li et al., (2021) & Customizing (2020)** who found that care bundle intervention significantly improves pupil reactivity in the experimental group.

The Effect Care Bundle on ICU Length of Stay

The current study hypothesized that patients who receive the care bundle intervention have shorter ICU stay than the control group who don't receive the intervention. The results revealed a highly significant reduction in the mean ICU length of stay in the study group post-intervention compared to the control group. These findings align with **Okidi et al., (2020)** who observed a significant decrease in ICU length of stay in the study group post-intervention. Consistent results were also reported by **Rubiano et al., (2021) & James et al., (2019)** both indicating a statistically significant reduction in ICU length of stay for TBI patients following care bundle interventions.

However, the results of this study are in contrast with **Patel et al., (2020)** who found that there no significant difference in the mean ICU length of stay among TBI patients was reported. A possible explanation of Patel's findings may be due to the advanced age and secondary brain injury prevalent in most participants, potentially contributing to an extended ICU length of stay.

Limitation of the study:

The findings of the current study are limited in their generalizability because of the purposive sample. The lack of random sampling may contribute to sample selection bias and limits the generalization of the findings.

Conclusion:

The implementation of a care bundle demonstrates enhanced hemodynamic parameters, improved oxygenation, elevated levels of consciousness, enhanced pupil reactivity, and reduced ICU length of stay in TBI patients.

Recommendations

- Develop clinical practice guidelines for critical care nurses to use care bundles as a routine to enhance hemodynamics, oxygenation, level of consciousness, and pupil reactivity in traumatic brain injury patients.
- Utilize insights from the current study to empower critical care nurses with a better understanding of diverse patterns and implementations of care bundles tailored to individual responses in traumatic brain injury patients.
- Replicate the study using a more heterogeneous sample to achieve an appropriate representation of the studied population and conduct the study in multiple settings.

Implications for Future Research

Further research is warranted to assess the impact of care bundles on achieving therapeutic ranges of Cerebral Perfusion Pressure (CPP) and Intracranial Pressure (ICP) in traumatic brain injury patients.

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