

## Effect of Educational Guidelines on Nurses' Performance Regarding Caring of Patients on Extracorporeal Membrane Oxygenation and Patient Outcomes

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### Abstract

**Background** Extracorporeal membrane oxygenation (ECMO) has become an important form of organ support for patients with severe circulatory or respiratory failure, as a bridge to recovery or more definitive treatment options. Therefore, this demands a more efficient performance by the nursing staff, to achieve optimum results. **Aim:** The study aims to assess the effect of educational guidelines on nurses' performance regarding caring for patients on extracorporeal membrane oxygenation and patient outcomes. **Design:** A quasi-experimental (one group pretest/posttest) design was utilized in this study. **Sample:** A convenience sample of all available nurses (50 nurses) and a convenience sample of 40 patients to assess patient outcomes. **Setting:** The study was conducted at a critical care unit affiliated to Sohag University Hospitals, Egypt. **Tools:** From the previous method setting, three tools were used to perform the study, 1- a Nurse Knowledge Assessment Questionnaire and 2- Nurse' Observational Checklist were utilized 3- patients outcomes questionnaire. **Results:** the result showed that that 54% of the studied nurses were between the ages of > 26- <35 years with a mean age of 31.82±7.6. About gender, 62% were males, 72% were single, and 86% had a bachelor's degree in nursing. And 96% of the studied nurses had a satisfactory level of knowledge and 98% of nurses had an adequate level of practice regarding ECMO post-implementing of intervention guidelines. Regarding to patient outcomes 37.5% of the studied patients have Acute respiratory failure as a medical diagnosis. About Types of ECMO Modalities, 77% were put on VV mode, and 75% were put on central ECMO cannulation also 15.76±4.33 was the mean number of days on ICU and 7.43±3.16 was the mean number of days on ECMO and 10.98±5.74 was the mean number of days on mechanical ventilator. Regarding ECHMO complications 15% of them had renal and pulmonary complications. **Conclusion:** Based on the results of the present study, it can be concluded that the implementation of educational guidelines had a statistically significant positive effect on total knowledge and practice satisfactory levels in the pre-, and immediate post-tests. There was a highly statistically significant difference regarding nurses' total level of knowledge and practice regarding ECMO complications rate, which supported the research hypothesis. **Recommendations:** Conduct training programs for the nurses caring for patients on ECMO machines. Providing nurses caring for patients on the ECMO machine with a designed instructional Arabic booklet and pamphlet regarding how to deal with the ECHMO machine.

**Keywords:** Extracorporeal membrane oxygenation, Nurses' performance, Outcomes

### Introduction

One of the newest intrusive medical technologies is extracorporeal membrane oxygenation (ECMO). For individuals with heart and lung issues who are unable to generate an appropriate gas exchange process to preserve life, it is a procedure that provides both cardiac and respiratory assistance. Patients with cardiac or respiratory issues are helped by ECMO. For example, respiratory disorders are unable to expel carbon dioxide or supply enough oxygen. Cardiac issues then prevent

the body from receiving enough blood flow. Additionally, patients awaiting an organ transplant (a new heart or set of lungs, for example) who suffer from heart or lung illness and cannot be treated may also receive support from ECMO (White & Fun, 2020).

Extracorporeal membrane oxygenation cannulations' indications include continuous blood pressure monitoring, frequent arterial blood-gas analysis, repeated blood sampling for laboratory evaluation, the measurement of the patient's vital

signs during an extended operation, introduction of other devices into the arteries, and performing heart surgeries. Whenever, arterial cannulation is contraindications in case of an absent pulse, thromboangiitis obliterans, full-thickness burns over the cannulation site, and inadequate circulation to the extremity. In addition, relative contraindications include anticoagulation, atherosclerosis, coagulopathy, and Infection at the cannulation site (Olson, et al 2021)

Extracorporeal membrane oxygenation is used for procedural support when more traditional methods of ventilation and oxygenation have failed, particularly in patients with intractable hypoxemia or acidosis from hypercarbia. Patients get a combination of pharmacologic neuromuscular blockade, prone positioning, inhaled pulmonary vasodilators, acute respiratory distress syndrome (ARDS) net, or other optimal modes of breathing, in part or in full, before starting. need should be restricted to individuals receiving a lung transplant or a pathway to recovery. Aspiration pneumonitis, blunt chest trauma, refractory status asthmatics, lung transplants, and ARDS from viral or inflammatory causes are among the indications (Tonna et al., 2021).

Because these patients are unstable and heavily dependent, providing nursing care to critically ill patients connected to ECMO is complicated. Patients require constant observation, frequent monitoring, a thorough examination from head to toe, and an evaluation of all bodily systems. Evaluation of vital signs, oxygen saturation, cardiac output, blood gas, laboratory values, urine output, catheter insertion sites, and fluid intake and output are also included (Mohamed, et al. 2023).

Oxygen is essential for life. Three systems respiratory, cardiovascular system, and hematological systems work together to ensure sufficient tissue perfusion with oxygen for all survival and proper function. Oxygen for all living cells is vital for cell activities & functions. The absence of oxygen can lead to death. Although the delivery of oxygen to body tissues is affected at least indirectly by all body systems, the respiratory system is the most system directly involved in the process of oxygenation directed to reduce risks and prevent potential complications for example, bleeding, cerebral

hemorrhage, respiratory tract infection, catheter insertion site infection, lower limb ischemia, urinary tract infection, coagulopathy, and provide psychological support for patients and their families (Bergeron & Holifield, 2020).

To prevent stress-induced ulceration, venous thrombosis, constipation, pressure ulcers, coagulopathy, and cerebral hemorrhage, nursing care for ECMO patients also entails regular physiotherapy, cautious device management, distress management, and nutritional assistance. Thus, ECMO usage and problem prevention should be taught to critical care nurses (Mohamed et al, 2019).

The role of nurses was found to be diverse and challenging and involved multiple responsibilities. Nurses worked with other healthcare providers in a team, which facilitated their performance. Nurses viewed themselves as competent to perform their role and attributed their competency mainly to the training received and the experience spent providing extracorporeal membrane oxygenation care (Alshammari, et al, 2020)

### **Significance of the study**

ECMO could serve as a bridge for lung transplantation. In a study of 40 patients with interstitial lung disease and respiratory failure, 21 were treated with ECMO. Eventually, 6 patients treated with support were bridged to lung transplant (Harnisch, et al .2020). According to estimates from the World Health Organization (WHO), 177 European centers have participated in the trial since March 15, 2020, and they have been regularly reporting on the ECMO support they offer to COVID-19 patients. Before the pandemic in 2019, the mean yearly number of ECMO cases treated in the collaborating sites was 55 (WHO, 2020).

An essential function of ECMO is to help patients with respiratory failure transition to lung transplantation. ECMO can stabilize the extraordinarily high fatality rates faced by patients with end-stage lung illness who experience an abrupt respiratory decompensating event (Michael & Ratano 2022). This underlined how crucial it is to research how educational guidelines affect nurses' performance when it comes to providing patient care

that affects extracorporeal membrane oxygenation and patient outcomes.

### **Aim of the study**

The study aims to assess the Effect of Educational Guidelines on Nurses' Performance regarding Caring for Patients on Extracorporeal Membrane Oxygenation and patient outcomes, the aim of this study was achieved through the following objectives:

1. Assess nurses' performance (knowledge and practice) regarding patients On Extracorporeal Membrane Oxygenation (ECMO) pre-implementation.
2. Develop and implement educational guidelines for nurses regarding patients On Extracorporeal Membrane Oxygenation (ECMO).
3. Evaluate the Effect of Educational Guidelines on Nurses' Performance regarding Caring for Patients on Extracorporeal Membrane Oxygenation and Patients Outcomes.

### **Research hypothesis**

H1- The Educational Guidelines will improve nurses' performance (knowledge and practice) post-implementation.

H2- The Educational Guidelines will positively impact patient outcomes post-implementation.

### **Operational definition**

Nurses' performance: means assessing nurses' knowledge and practice.

### **Subjects & Methods**

The subject and methods for this study were portrayed under the four main designs as follows:

- I. Technical design.
- II. Operational design.
- III. Administrative design.
- IV. Statistical design

#### **(I)- Technical Design:**

The technical design included research design, settings, and tools for data collection.

#### **Research design:**

A quasi-experimental design was utilized in this study. Quasi-experimental research is an empirical interventional study to examine causal relationships or determine the effect of one variable on another. Thus, these studies involve implementing a treatment or intervention and examining the effects of this intervention using selected methods of measurement. Quasi-experimental studies differ from experimental studies by the level of control achieved by the researcher. These studies usually lack a certain amount of control over the manipulation of the treatment, management of the setting, and/or selection of the subjects (Miller et al., 2019).

#### **Setting:**

The study was conducted at a critical care unit affiliated with Sohag University Hospitals, Egypt. This Unit is on the 2nd floor and consists of 17 beds and has 6 extracorporeal membrane oxygenation (ECMO) machines.

#### **Subjects:**

#### **Nurses sample.**

A convenient sample of all available nurses (50) working in the previously mentioned setting, who provide care for patients connected with extracorporeal membrane oxygenation machine.

#### **Patient sample**

A convenient sample of (40) Patients on Extracorporeal Membrane Oxygenation

#### **Sample size calculation**

The sample size was calculated based on a study carried out by Mohamed et al. (2023). By estimating an effect size of 0.60, based on the mean number of extracorporeal membrane oxygenation questionnaire was 30.65 and  $25.7 \pm 7.21$  and statistical power of 80%, level of confidence (1-Alpha Error): 95%, Alpha 0.05, Beta 0.1. Alpha 0.05, Beta 0.1. The sample size will be 40 patients. Considering 10% sample attrition (10 patients), the final sample size is 40. The sample size is calculated using a test comparing two means through Kane SP. Sample Size Calculator. ClinCalc (Kang, 2011).

#### **Tools for data collection:**

Data was collected using the following tools:

**Tool I: Self- Self-administered Interview Questionnaire:** It was designed by the investigator based on reviewing related literature review (Kapoor, 2014 and Brogan, 2019) and written in simple Arabic

language to gather data regarding the following two parts:

**Part I: Nurses' Demographic Characteristics**

**Data:** It includes data such as nurses' age, gender, educational level, years of experience in the field of nursing, years of dealing with ECMO patients, and attendance of training courses about the care of patients connected with ECMO.

**Part II: Nurses' Knowledge Assessment**

**Questionnaire:** Regarding Care of Patients Connected with ECMO: It was developed by the investigator to assess nurses' knowledge regarding the care of patients connected with ECMO which covers all the general and basic information about ECMO. It includes definition (2 questions), types (2 questions), uses (4 questions), complications (5 questions), contraindication (4 questions) and nursing management (13 questions).

**Scoring system:**

Each correct answer was given one degree, and the incorrect answer was given zero. The total score was 30 degrees.

**The total score of knowledge was 30 degrees it was considered that**

*≥90% Satisfactory level of knowledge (≥ 27 degrees)*

*<90% unsatisfactory level of knowledge (< 27 degree)*

**Tool II: Nurses' Observational Checklist:**

Regarding Care of Patients Connected with ECMO: It was adopted by (Kapoor, 2014) to assess nurses' practice regarding the care of patients connected with ECMO. It includes the following 3 parts:

**Part I:** Nurses' practice regarding the pre-procedure steps. It includes hand hygiene, and preparing needed equipment, (5 steps).

**Part II:** Nurses' practice regarding general care of the ECMO patient. It includes management of each system in the patient body system as Hemodynamic management (6 steps), anticoagulation management (3 steps), hematology management (2 steps), respiratory management (4 steps), renal management

(5 steps), neurological management (5 steps), gastrointestinal management (3 steps), nutritional management (4 steps), and integumentary management (6 steps).

**Part III:** Nurses' practice regarding special care of ECMO as machine safety checks (6 steps), circuit assessment (6 steps), oxygenator assessment (4 steps), heat exchanger assessment (5 steps), ventilator setting checks (2 steps), emergency plan (6 steps), ECMO cannula and lines monitoring (5 steps).

**Part (VI):** Post-procedure, contains (1 step).

**Scoring system**

Each correct step done was given one degree, while the step which was done incorrectly or not done was given zero, the total score was 78 degrees.

**The total score of nurses' practice was 80 degrees, it was considered that:**

- ≥90% was the competent level of the nurse's practice (≥ 70 degrees).
- <90% was a competent level of the nurse's practice (< 70 degree).

**Tool (III): patient outcomes questionnaire**

This tool was developed by the researcher after reviewing related literature (Brogan, 2019). It consisted of two parts:

**Part(1): patient's Demographic characteristics:**

This part includes demographic characteristics of the studied patients such as (Age, gender, educational level, and occupation,).

**Part(2): Patient's outcomes:**

It was used to assess patient outcomes through (medical diagnosis, ECMO modalities, type of ECMO cannulation, duration on ECMO, duration in ICU, duration on mechanical ventilator, Mortality rate, atrial blood gases parameters, and complication of patients on ECMO).

## **(II): Operational design:**

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It included the preparatory phase, face and content validity & reliability, Pilot study, and fieldwork.

### **The Preparatory phase:**

This phase involved reviewing the recent national and international related literature, and theoretical knowledge of various aspects of the study using books, articles, the internet, and periodicals. Etc. to develop the study tools and test their validity and reliability.

### **Validity & Reliability:**

#### **Validity:**

The tools were revised by a panel of five experts from the Medical-Surgical academic staff, at Ain Shams University. The experts reviewed the tools for clarity, relevance, comprehensiveness, and simplicity, and minor modifications were made accordingly. Content validity for tool I (nurses' knowledge) was 80% to 100% and for tool II (nurses' observational checklist) was 80 % to 100%, tool III (patients outcomes questionnaire) was 80%.

#### **Reliability:**

The reliability of tools was tested statistically using Cronbach's Alpha coefficient test which revealed that the tools of the study were reliable as indicated by the value for tool I (nurses' knowledge) was 0.824 and for tool II (nurses' observational checklist) 0.848, tool III (patients outcomes questionnaire) was 0.865.

#### **Pilot Study:**

A pilot study was carried out on 10% (5 nurses and 5 patients) of sample size to test the feasibility and applicability of the research process and clarity of the tools and time required to fill them. Necessary modifications were made according to the result of a pilot study.

#### **Ethical consideration:**

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The study obtained ethical approval from the Institutional Review Board of the Faculty of Nursing at Sohag University In addition to this, the researcher obtained oral consent from nurses after providing them with a clear understanding of the

study's objectives. Moreover, nurses who consented to participate were guaranteed the confidentiality of all data collected during the study, and they maintained the right to withdraw from the study at any time. The questionnaires were completed anonymously, and the data collected were handled with the utmost confidentiality, exclusively for research purposes.

### **Fieldwork:**

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#### **A. Assessment and Planning phase**

This phase was implemented through the following steps:

- Interviewing with nurses under study to explain the aim of the study and get their approval before any data collection. The researcher visited one of the selected three units, three days/week in the morning & afternoon shifts (Saturday, Monday, and Wednesday) the data collection took 6 months and started from June 2023 to December 2023.
- The researcher observed the nurses during their actual work in the morning & afternoon shifts while caring for patients in ICUs, about 1- 2 nurses / shift in each selected unit per week by using an observational checklist and a self-administered questionnaire was filled by each nurse included in the study, it took about 45 minutes.
- Then the researcher followed the following successive manner in collecting data from the patients in the selected unit, whereas the patient outcomes parameters assessment form including demographic & medical data was filled by the researcher either from the patients themselves or from families & medical records in case of unconscious patients. As well as other patient outcomes parameters complications & mortality rates were taken from medical records.
- Regarding complications, the researcher assessed each patient during their stay in ICUs for any signs & symptoms that were associated with each complication, around 1 to 2 patients /shifts, this tool took about 60 minutes for each patient. After the researcher fills filling the data from the patients in the selected unit.

- The booklet's theoretical substance focused on comprehending every facet of the ECMO machine, including its accessories, definition, configuration, indications, contraindications, and problems. The nursing care of patients on ECMO was the focus of the practical portion. To verify its legitimacy, a panel of critical care, medical, and nursing specialists examined the instruction booklet.
- After that, the researcher developed an educational guideline about ECMO based on the recent results obtained from the nurse's performance assessment & the recent national & international literature (White & Fun, (2020); Mohamed, et al. 2023). The assessment & planning phase took about 3 months.

### **B. Implementation phase**

- The researcher implemented an educational guideline related to ECMO covering all its components for caring for patients in ICUs in the form of scientific sessions according to timetable taking into consideration the nurses working time in ICUs.
- Educational guidelines include the following parts: Part I: Overview of ECMO. Part II: nurses role during care for patient on ECMO. Part III: Information about patient outcomes parameters including complications The nurses in this study were divided into small groups, each group consisting of 5-8 nurses, the program included 4theoretical sessions implemented in the morning & afternoon shifts for three days /week in one of the selected unit, the duration of each session took about one hour, while the 8 practical program sessions were provided by teaching on spot (on the job training).
- In addition, one session was conducted at the beginning of the program for orientation & pre-test application while another session was conducted at the end of the program for revision and post-test application.
- The researcher started with the studied nurses' greeting, motivation, and reinforcement techniques as praise and recognition during the educational program sessions to enhance learning. Orientation about the aims of the

educational program, time, and content was done using simple words and a tone of voice that showed interest and concern.

- Each session started with a summary of what was given in the previous session and the objectives of the new topics were mentioned, taking into consideration using simple language to suit the level of the nurses. Each session included new topics with general and specific objectives, involving attractive media and methods.
- A different teaching strategy was used in implementing the educational guidelines, e.g. discussion, direct application, role play, booklet, photos, videos, and posters. To ensure the exposure of all nurses to the same learning experience, each group received the same educational guidelines and content and used the same teaching strategies.
- In addition, the researcher developed a booklet in Arabic language covering the ECMO machine its components &management based on the level of nurses' qualifications the illustration of selected pictures matched with content, to easily memorize it. The researcher distributed the designed manual booklet to each participant to clarify the desired knowledge and skills.
- The educational program content is covered in about two months & the same manner is followed in other selected units. So the implementation phase took about 3 months.
- The assessment & planning and implementation phase took about 6 months.

### **Evaluation phase**

This phase included evaluating the effect of educational guidelines on nurses' performance (knowledge & practice) regarding ECMO for caring for patients in ICUs & patient outcomes parameters using the above-mentioned data collection tools.

Evaluation of nurses' performance was done immediately post-program implementation. As well as evaluation of patients outcomes parameters were evaluated twice from pre and immediate post-program implementation.

### (III): Administrative design

Approval to carry out this study was obtained from the Dean of the Faculty of Nursing and the directors of Sohag University Hospital. Subjects consent was obtained for data collection after explaining the purpose of the study.

### IV: Statistical design

Data were analyzed using the statistical package for social sciences, version 22.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

#### The following tests were done:

- A chi-square ( $\chi^2$ ) test of significance was used to compare proportions between qualitative parameters.
- Pearson's correlation coefficient ( $r$ ) test was used to assess the degree of association between two sets of variables
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

#### Probability (P-value)

- P-value  $<0.05$  was considered significant.
- P-value  $<0.001$  was considered as highly significant.
- P-value  $>0.05$  was considered insignificant.

### Results:

**Table (1)** shows that 54% of the studied nurses were between the ages of  $> 26- <35$  years with a mean age of  $31.82 \pm 7.6$ . About gender, 62% were males, 72% were single, and 86% had a bachelor's degree in nursing. Concerning years of experience, it was revealed that 50% of nurses had less than one

year of experience. Also, about 62% of the studied nurses didn't attend any training courses about caring for patients on ECMO.

**Table (2)** shows that all (100%) of the studied nurses have a satisfactory level of knowledge regarding the Definition of ECMO, and ECMO complications post-implementation of interventional guidelines. In addition, 98% of the nurses had a satisfactory level of knowledge regarding Contraindication of ECMO post interventional guidelines implementation compared with 60% pre-intervention implementation. Regarding nurse's knowledge about Types of ECMO, it was revealed that 96% of nurses had a satisfactory level of knowledge post-interventional guidelines implementation compared with 58% pre-intervention guidelines implementation with a highly statistically significant difference pre and post where  $p\text{-value} < 0.001$ .

**Figure (1)** shows that 96% of the studied nurses had a satisfactory level of knowledge post-intervention implementation compared to 40% pre-implementation.

**Table (3)** shows a highly statistically significant difference in nurses' practice through all phases of caring for patients on ECMO. The table illustrated that 100% of the studied nurses adequate level of practice regarding the General Care of the patient on the ECMO machine, the nurse's role for the ECMO machine, and post-procedure, 96% of them had an adequate level of practice pre-procedure steps, post implementation of intervention guidelines, compared with 60%, 46%, 42%, and 22%, 50% respectively before guidelines intervention with a highly statistically significance pre and post where  $p\text{-value} < 0.001$ .

**Figure (2)** shows that about two-thirds (98%) of the studied nurses had an adequate level of total practice post-intervention implementation compared to 30% pre-implementation.

**Table (4)** shows a statistically significant positive correlation between total nurses' knowledge and total level of practice scores post guidelines intervention implementation where  $p \leq 0.001$ .

**Table (5)** shows that 55% of the studied patients were between the age of  $> 35- <50$  years with a mean age of  $38.62 \pm 9.6$ . Regarding gender,

52.5% were males, 65% were married and 50% had a University education. Regarding occupation, it was found that 70% of them are working. Also, about 72.5% of them live in urban areas.

**Table (6)** shows that 37.5% of the studied patients have Acute respiratory failure as a medical diagnosis. About Types of ECMO Modalities, 77% were put on VV mode, and 75% were put on central ECMO cannulation also  $15.76 \pm 4.33$  was the mean number of days on ICU and  $7.43 \pm 3.16$  was the mean number of days on ECMO and  $10.98 \pm 5.74$  was the mean number of days on mechanical ventilator.

Regarding ECHMO complications 15% of them had renal and pulmonary complications.

This table illustrates that; there was a statistically significant difference between the patient's results regarding arterial blood gas mean scores including PH, Pco<sub>2</sub>, PO<sub>2</sub>, HCO<sub>3</sub>, and oxygen saturation at p-value (< 0.001).

**Table (8)** reveals that there was a positive correlation with highly statically significant differences between the studied nurses' total knowledge and practice scores and patient outcomes parameters immediately post-program implementation with p-value < 0.001.

**Table 1:** Number and percentage Distribution of Nurses Regarding Their Demographic Data (N=50).

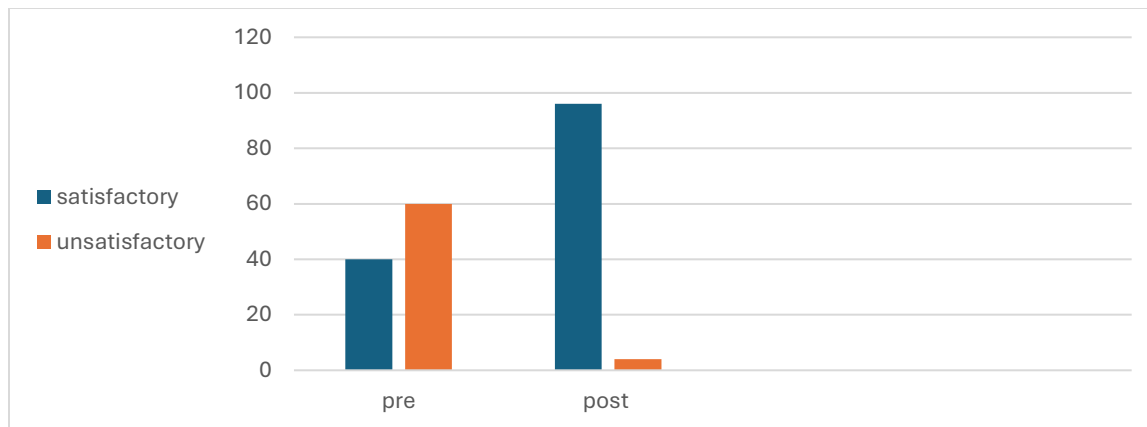
Demographic data	N	%
<b><u>Age/year</u></b>		
≤25	9	18.0
26-35	27	54.0
>35	14	28.0
Mean and SD	31.82±7.61	
<b><u>Gender</u></b>		
Male	31	62.0
Female	19	38.0
<b><u>Marital Status</u></b>		
Single	36	72.0
Married	14	28.0
<b><u>Nursing educational qualifications</u></b>		
Bachelor's degree in nursing	43	86.0
Technical diploma	6	12.0
Diploma in Nursing	1	2.0
<b><u>Years of experience</u></b>		
< 1 years	25	50.0
1<5 years	20	40.0
5<10 years	4	8.0
≥10 years	1	2.0
<b><u>Attended training courses</u></b>		
No	31	62.0
Yes	19	38.0



**Table (2):** Comparison between the studied nurses' total level of knowledge regarding ECMO pre, & post-program implementation (N=50).

Knowledge	Pre		Post		Pre-post Test	
	N	%	N	%	$\chi^2$	P value
Definition of ECMO	41	82	50	100	9.89	0.002**
Types of ECMO	29	58	48	96	20.38	0.000**
Uses of ECMO	30	60	44	88	10.18	0.001**
ECMO complication	35	70	50	100	17.64	0.000**
Contraindication of ECMO	30	60	49	98	21.76	0.000**
Nursing management for patients on ECMO	26	52	46	92	19.84	0.000**

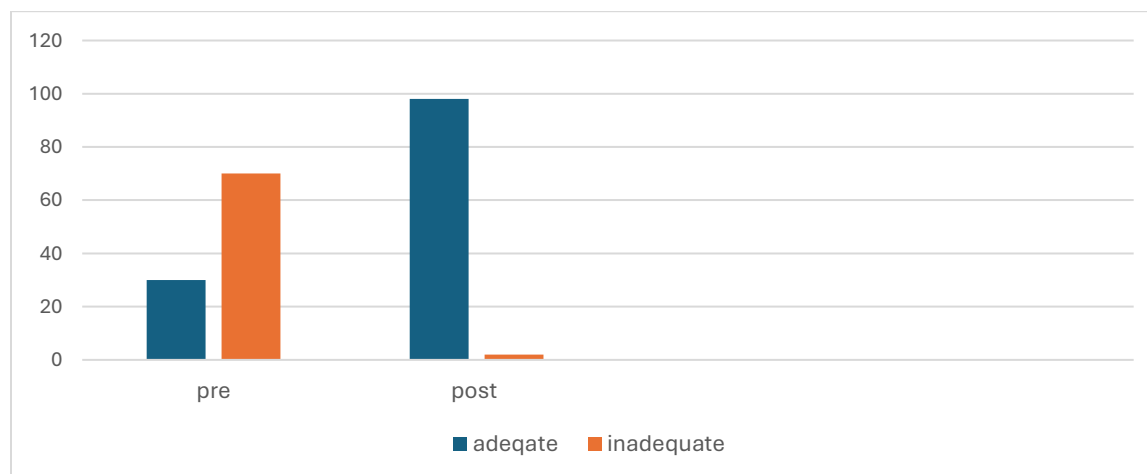
\*P≤ 0.001 highly significant



**Figure (1):** Percentage distribution of nurses' total level of knowledge about caring for patients on ECMO (n=50).

**Table 3:** Comparison between the studied nurses' total level of practice regarding ECMO pre-, & post-program implementation (N=50).

Practice	Pre		Post		Pre-post Test	
	N	%	N	%	$\chi^2$	P value
A- Pre- Procedure	41	82	48	96	5.005	0.025*
<b>B- General Care of the patient on an ECMO machine</b>						
Hemodynamic Management	25	50	50	100	33.33	0.000**
Anticoagulation Management	10	20	48	96	59.27	0.000**
Hematology Management	27	54	50	100	29.87	0.000**
Respiratory Management	32	64	50	100	21.95	0.000**
Renal Management	24	48	48	96	28.57	0.000**
Neurological Management	8	16	50	100	72.41	0.000**
Gastrointestinal Management	43	86	50	100	7.52	0.006*
Nutritional status management	37	74	50	100	14.94	0.000**
Integumentary Management	21	42	48	96	34.08	0.000**
<b>Total</b>	30	60	50	100	25.00	0.000**
<b>C-Nurses ROLE for ECMO machine</b>						
Machine Safety Checks	28	44	50	100	28.20	0.000**
Circuit Assessment	32	64	50	100	21.95	0.000**
Oxygenator Assessment	23	46	50	100	36.98	0.000**
Heat Exchanger Assessment	40	80	50	100	11.11	0.001**
Ventilator Setting Checks	11	22	49	98	60.16	0.000**
Emergency Plan	14	28	50	100	56.25	0.000**
ECMO cannula and lines monitoring	36	72	49	98	13.25	0.000**
<b>Total</b>	23	46	50	100	36.98	0.000**
<b>D- Post-procedure</b>	21	42	50	100	40.84	0.000**

\*P $\leq$  0.001 highly significant**Figure (2):** Percentage distribution of nurses' total level of practice about caring for patients on ECMO (n=50).

**Table (4): Correlation between the studied nurse's total scores of knowledge & practice regarding the ECMO pre, & post of the program implementation (N=80).**

Item	The total level of knowledge	
	Pre-Program	Post-Program
Total score of practice	0.185	0.571
	0.453	≤0.001**

#### Patients' outcomes

**Table 5: Number and percentage distribution of patients regarding their demographic data (N=40).**

Demographic data	N	%
<b><u>Age/year</u></b>		
20 - < 35 years	8	20
35 - < 50 years	22	55
50 - 60 years	10	25
$\bar{x} \pm SD$	38.62±9.6	
<b><u>Gender</u></b>		
Male	21	52.5
Female	19	47.5
<b><u>Marital Status</u></b>		
Single	14	35
Married	26	65
<b><u>Education level</u></b>		
Not read and write	4	10
Read and write	3	7.5
Secondary education	13	32.5
University education	20	50
<b><u>Occupation</u></b>		
Working	28	70
Doesn't work	12	30
<b><u>Residence</u></b>		
Urban	29	72.5
Rural	11	27.5

Table 6: Number and percentage distribution of patients regarding their clinical data and complication (N=40).

Item	Result	
	No	%
<b>Medical diagnosis</b>		
Circulatory shock	8	20
Hypoxia or hypercapnia	11	27.5
COVID	6	15
Acute respiratory failure	15	37.5
<b>Types of ECMO Modalities</b>		
VA	12	30
VV	28	70
<b>Type of cannulation</b>		
Peripheral	10	25
Central	30	75
<b>Number of days in ICU</b>	15.76±4.33	
<b>Number of days on ECMO</b>	7.43±3.16	
<b>Number of days on a mechanical ventilator</b>	10.98±5.74	
<b>Complications from ECMO machine</b>		
Renal	6	15
Hematological (bleeding)	5	12.5
Neurologic	3	7.5
Pulmonary	6	15
Cardiac	4	10
Infection	10	25
<b>Mortality</b>	5	12.5

Table 7: Comparison between blood gas results pre and post-intervention (N=40).

Item	Pre	Post	Kruskal Wallis test
<b>PH</b>	pH 7.40 ± 0.1	pH 7.36 ± 0.1	15.324**
<b>PACO2</b>	54.7 ± 2.5 mmHg	48.5 ± 3.4 mmHg	15.184**
<b>PO2</b>	45.4 ± 5.2 mmHg	70.4 ± 6.7 mmHg	14.641**
<b>HCO3</b>	33.5 ± 5.2 mEq/L	26.4 ± 2.1 mEq/L	16.043**
<b>SpO2</b>	90.45 ± 2.5	95.45 ± 3.4	14.925**

$\bar{x}$ : mean; SD: Stander deviation; and \*\*significant = p-value  $\leq$  0.001

Table (8): Correlation between the studied nurses' total knowledge and practice scores and patient outcomes parameters post-implementation.

Complication	Total knowledge				Total practice			
	Pre		Post		Pre		Post	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
<b>Renal</b>	0.155	0.200	0.590	$\leq$ 0.001**	0.144	0.233	0.654	$\leq$ 0.001**
<b>Hematological (bleeding)</b>	0.191	0.153	0.541	$\leq$ 0.001**	0.162	0.198	0.608	$\leq$ 0.001**
<b>Neurologic</b>	0.152	0.211	0.525	$\leq$ 0.001**	0.153	0.207	0.417	$\leq$ 0.001**
<b>Pulmonary</b>	0.082	0.357	0.528	$\leq$ 0.001**	0.151	0.231	0.608	$\leq$ 0.001**
<b>Cardiac</b>	0.090	0.288	0.533	$\leq$ 0.001**	0.281	0.105	0.566	$\leq$ 0.001**
<b>Infection</b>	0.264	0.120	0.600	$\leq$ 0.001**	0.117	0.274	0.660	$\leq$ 0.001**
<b>Mortality</b>	0.120	0.236	0.556	$\leq$ 0.001**	0.143	0.236	0.491	$\leq$ 0.001**

\*\*p-value < 0.001 is highly significant

## Discussion

In emergency departments (EDs) or critical care units (ICUs), extracorporeal membrane oxygenation (ECMO) is a mechanical cardiorespiratory support technique utilized in complex patients. Patients receiving critical care, such as those experiencing cardiac arrest (CA) and acute respiratory distress syndrome, benefited greatly from the use of extracorporeal membrane oxygenation (ECMO). As ECMO guarantees the patient receives enough cerebral blood flow (CBF) and maintains organ perfusion, it is progressively demonstrating its benefits in terms of speed and efficacy of circulatory support. Neurological prognosis is improved and patient survival is increased with ECMO. On the other hand, because of the high fatality risk and unfavorable outcomes that come with ECMO, brain problems are also significant (Puślecki, et al., 2018).

With the data, it can be known that ECMO interventional guidelines improve patient safety by strengthening the skills required for rapid management, fewer errors, and higher levels of confidence during the management of ECMO and decreased complications. Regarding nurses' characteristics, the result showed that more than half of the studied nurses were between the ages of > 26- <35 years with a mean age of  $31.82 \pm 7.6$ . About gender, less than two-thirds of them were males, and less than a quarter were single, while the majority of the studied nurses had bachelor's degrees. Concerning years of experience, it was revealed that half of nurses had less than one year of experience. Also, less than two-thirds of them didn't attend any training courses about caring for patients on ECMO.

According to **Shaban et al.'s (2019)** study, "Effect of Educational Program About Care of Patients Connected to Extracorporeal Membrane Oxygenation (ECMO) on Nurses Knowledge and Practices," adult married female diploma nurses were more common than male diploma nurses and had less experience caring for critically ill patients connected to ECMO. They did not participate in any CEUs related to patient care for ECMO patients. The traditional Egyptian nursing school system, which emphasizes the value of improving knowledge and practice and the necessity for nurses to pursue ongoing training, maybe the reason for this, according to the investigator.

Regarding to satisfactory level of total knowledge the result of the present study showed that all of the studied nurses have a satisfactory level of knowledge regarding the definition of ECMO, and ECMO complications post-implementation of interventional guidelines in addition, almost all of the nurses have a satisfactory level of knowledge regarding Contraindication of ECMO post interventional guidelines implementation compared with less than two-third pre-intervention implementation. Regarding nurse's nurses' knowledge about Types of ECMO, it was revealed that almost of nurses had correct knowledge of post-interventional guidelines implementation compared with more than half of pre-pre-intervention guidelines implementation with a highly statistically significant difference pre and post where  $p$  value < 0.001.

This is in line with the findings of Kim et al.'s (2018) study, "The Effect of an Improvement of Experience and Training in extracorporeal membrane oxygenation management on clinical outcomes," which discovered that critical care nurses' knowledge of how to care for patients on ECMO was assessed. The study sample's knowledge scores on the definition, indications, contraindications, and complications of ECMO improved significantly with immediate program implementation compared to pre-program knowledge scores, with statistically significant differences.

The current study discovered that, in terms of a total satisfactory level of knowledge, nearly all of the nurses under investigation had a satisfactory level of knowledge following the implementation of the intervention, as opposed to just 25% before it. This study's findings showed According to Jones-Akhtarekhavari et al. (2017), who studied the development of a successful ECMO program, there were significant statistical differences in mean knowledge scores regarding complications associated with ECMO after program implementation as compared to before. Increased experience or familiarity with ECMO management increased patients' chances of survival and decreased potential complications. These findings are consistent with their research. Enhancing critical care nursing practice and knowledge "from the investigator's point of view" will therefore be reflected in patients' care.

It is expected to increase critically ill patients' survival rate and prevent suspected complications.

Regarding to total adequate level of practice the present study found a highly statistically significant difference in nurses' practice through all phases of caring for patients on ECMO. The table illustrated that all of the studied nurses practiced the correct steps regarding general care of the patient on the ECMO machine, the nurse's role for the ECMO machine, and Post-procedure, almost of them practiced correctly the steps pre-procedure steps, post implementation of intervention guidelines, compared with less than two-third, less than half, and one fifth, half respectively before guidelines intervention with a highly statistically significance pre and post where  $p\text{-value} < 0.001$ . This result agreed with **Tonna, et al (2017)**, in the study "Development and Implementation of a Comprehensive, multidisciplinary Emergency Department extracorporeal membrane oxygenation program," nurses the study demonstrated a level of practice that was satisfactory for caring for catheters and the entire circuit, with a statistically significant difference in practice scores across all assessment times.

Regarding to total adequate level of practice the present study found that almost all of the studied nurses had an adequate level of total practice post-intervention implementation compared to less than one-third pre-implementation. This finding is in agreement with **Cavarocchi, et al (2015)**, study (The effect of an improvement of experience and training in extracorporeal membrane oxygenation management on clinical outcomes) which reported that the program's effectiveness in preserving patient safety and enhancing results for nurses was demonstrated by the study, which showed that nurses' practices improved after putting it into place as opposed to before, with a substantial statistical difference in the mean practice scores.

To assess and enhance the abilities of 45 critical care nurses in the management of patients on ECMO, Thomas (2019) conducted a study at Queen Mary Hospital in Hong Kong. The program's objective was to construct a nurse-led simulation-based educational program. The study revealed that nurses lacked expertise in caring for and managing critically ill patients who were on ECMO. The program has shown its contribution to improved

patient outcomes and safer clinical ECMO services. Therefore, patient care will improve as a result of critical care nurses' improved practices "from the investigator's point of view". It is anticipated to enhance the survival rate of critically ill patients, avoid suspected complications, and enhance patient outcomes.

According to the relation between nurses' knowledge and practice the present study found a statistically significant positive correlation between total nurses' knowledge and total level of practice scores post guidelines intervention implementation where  $p \leq 0.001$ . this result matched with **Cotza, et al (2016)**, study entitled (Modern ECMO: why an ECMO Program in a Tertiary care hospital) which emphasized the significance of ongoing evaluation and improvement of nursing practices and knowledge in the care of patients who are severely sick. After the instructional program was put into place, critical care nurses who were assigned to care for patients who were on ECMO demonstrated sufficient knowledge and experience in caring for critically ill patients. The program demonstrated a notable enhancement in the knowledge and practices of nurses. The initial study hypothesis is therefore validated.

### Patients' outcomes

Regarding patients' characteristics, the result showed that more than half of the studied patients were between the ages of  $> 35$ -  $< 50$  years with a mean age of  $38.62 \pm 9.6$ . Regarding gender, more than half were males, less than two-thirds were married and half had a University education. Regarding occupation, it was found that less than three-quarters of them are working. Also, less than three-quarters of them live in urban areas. This result does not agree with **Na, et al.'s (2018)**, study titled (The effect of multidisciplinary extracorporeal membrane oxygenation team on clinical outcomes in patients with severe acute respiratory failure) which found that more than half of the studied patients' ages ranged between 51-65 years old, the mean  $\pm$  SD of age was  $57.16 \pm 7.56$  years and more than two-thirds of patients were male, less than three-quarters of them were married, more than one-third of the studied patients were working, also less than one-third of the studied patients were illiterate and secondary education.

According to patient clinical data, the present study found that more than one-third of the studied patients have Acute respiratory failure as a medical diagnosis. Regarding types of ECMO modalities, more than three quarters were put on VV mode, and three quarters were put on central ECMO cannulation also  $15.76 \pm 4.33$  was the mean number of days on ICU and  $7.43 \pm 3.16$  was the mean number of days on ECMO and  $10.98 \pm 5.74$  was the mean number of days on mechanical ventilator. Regarding ECHMO complications less than one-fifth of them had renal and pulmonary complications.

This result was not supported by **Kim, et al (2018)**, Who found that the most common disease requiring ECMO support was pneumonia (43.4%). This result was supported by **Ng, et al (2022)**, the study titled (Effect of hospital case volume on clinical outcomes of patients requiring extracorporeal membrane oxygenation: a territory-wide longitudinal observational study) who found that one-third of patients put on veno-arterial extracorporeal membrane oxygenation, and half of them put on venovenous extracorporeal membrane oxygenation, also more than half using central cannulation.

This finding by **Na et al (2018)** when assessing the mortality rate who found that the mortality rates in the intensive care unit (72.9 vs. 50.0%,  $P = 0.012$ ) and hospital (75.7 vs. 52.2%,  $P = 0.009$ ) were significantly decreased in the post-ECMO team period compared to the pre-ECMO team period. This finding agrees with that of **Jones-Akhtarekhavari et al (2017)**. In the current study, nurses' knowledge of mechanical complications related to ECMO was assessed. The results showed a significant statistical difference in the mean knowledge scores regarding ECMO complications after the program was implemented compared to before. This led to an increase in experience or familiarity with ECMO management, as well as an increase in patient survival and a reduction in potential complications. From "the investigator's point of view," it is anticipated that increased nursing staff knowledge will improve patient care and avert potential consequences.

Regarding compression between arterial blood gases results the result found that; there was a statistically significant difference between the patient's result regarding arterial blood gases mean

scores including PH, Pco<sub>2</sub>, PO<sub>2</sub>, HCO<sub>3</sub>, and oxygen saturation at p-value ( $< 0.001$ ). This result was in agreement with **Kourek et al, (2022)**. the study entitled (Modalities of exercise training in patients with extracorporeal membrane oxygenation support) reported that COVID-19 patients with respiratory and physical problems benefit from physiotherapy expertise through telerehabilitation programs, which include intercostal muscle stretching, chest wall vibration, walking short distances, and breathing exercises lead to improve respiratory function and ABG parameters with significance differences. Also, this finding is the same with **Dyk. (2018)**. the study entitled (Physiotherapy for ECMO Patients) mentioned that early physiotherapy and mobilization for patients improve respiratory function and prevent complications.

Regarding the correlation between nurses' total level of knowledge and practice and patients' outcomes, there was a positive correlation with highly statically significant differences between the studied nurse's total knowledge and practice scores and patients' outcomes parameters immediately post-program implementation with a p-value  $< 0.001$ . this result was supported by **Pereira, et al (2021)** the study entitled (Clinical outcome of patients undergoing extracorporeal membrane oxygenation after multidisciplinary training) who mentioned that the impact of training on in-hospital death rate and 90-day survival is an incentive for hospital managers to adopt the training model with their teams to ensure better quality care and decrease patient complication with statically significant differences.

This result was in agreement with **Lucchini et al (2019)**. the study entitled (The Evaluation of Nursing Workload within an Italian ECMO Centre: A Retrospective Observational and Educational Study) found that an educational program improves nurses' level of knowledge and practice and prevents patient complications. From the researcher's point of view this may be due to improving nurses' performance affect positively on patient outcomes and improve patient prognosis. So, the second research hypotheses are supported.

## Conclusion

Implementation of educational guidelines had a statistically significant positive effect on total

knowledge and practice satisfactory levels in the pre-, and immediate post-tests.

There was a highly statistically significant difference regarding nurses' total level of knowledge and practice regarding ECMO complications rate, which supported the research hypothesis.

## Recommendations

### Based on the current study findings,

1. Conducting training programs for the nurses caring for patients on ECMO machines.
2. Providing nurses caring for patients on the ECMO machine with a designed instructional Arabic booklet and pamphlet regarding how to deal with the ECHMO machine.
3. Involves the use of different care protocols for patients on ECHMO machines in the context of evidence-based practice.
4. To enhance nurses' knowledge and skills, ongoing in-service training and workshops should be offered.
5. Theoretical and practical instruction on caring for patients on ECMO must be covered in nursing curricula. Nurses' practices must also be continuously assessed and observed to spot any areas where they fall short in providing care for these patients.
6. Giving critical care nurses clear instructions on the nursing administration and assessment of patients on ECMO
7. Researching to assess the impact of an educational program on patient outcomes and replicating the study on a sizable probability sample drawn from various Egyptian regions.

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