Section A -Research paper

Nurses' Knowledge and Practice Regarding Care of Patients Connected with Extracorporeal Membrane Oxygenation

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ABSTRACT

Background: Extracorporeal Membrane Oxygenation (ECMO) is an advanced life support machine being used with patients with respiratory failure and/ or cardiac failure. ECMO is a complicated medical care that requires diligent nursing care. Critical care nurses with the knowledge and practice can potentially reduce the risks of morbidity and mortality in these patients**. Aim:** to assess the nurses' knowledge and practice regarding care of patients connected with ECMO. **Design:** A descriptive exploratory design was utilized in this study. **Setting:** The study was conducted at critical care department at Cairo University Hospitals. (Critical care unit in Qasr Al-Aini Hospital). **Sample:** A convenience sample of all available nurses (60 nurses) from both genders. ***Tools*:** Data were collected by using two tools; the first tool is self- administered interview questionnaire, and the second tool is nurses' observational checklist regarding care of patients connected with ECMO. **Results:** the current study showed that 88.3% of studied nurses had a satisfactory level of knowledge regarding care of patients connected with ECMO, and 78.3% of studied nurses had a competent level of practice regarding care of patient connected with ECMO, there wasn't a statistically significant relation between total level of knowledge regarding care of patients connected with ECMO and demographic characteristics, while there was a highly statistically significant relation between total level of practice regarding to care of patients connected with ECMO and demographic characteristics. **Conclusion:** there were highly statistically significant positive correlations between the studied nurses' total level of knowledge and their total level of practice regarding care of patients connected with ECMO. **Recommendations:** Continuing assessment of nurses' knowledge and practice, continuous training courses should be conducted for nurses to improve their knowledge and practice and to increase their performance regarding care of patients with ECMO.

Keywords: *Nurses' knowledge, Nurses' practice, Extracorporeal Membrane Oxygenation.*

Introduction

Extracorporeal membrane oxygenation (ECMO) is one of new invasive devices. It is a technique of providing both respiratory and cardiac support for patients with heart and lungs problems that are unable to provide an adequate gas exchange process to sustain life. ECMO is used for help patients whose have cardiac or respiratory problems. For instance, lung problems as cannot provide sufficient oxygen or get rid of carbon dioxide. Then, cardiac problems as cannot pump enough blood to the body. Moreover, ECMO may also be used for support patients with heart and/or lung disease that cannot be cured while wait for an organ transplant (e.g., new heart and/or lungs). **(White & Fan, 2016)** [(25)]

Nursing care of those critically ill patients who connected with ECMO is complex because those patients are unstable and highly dependent. Patients need frequent monitoring, close and good observations, and complete assessment from head and toe, assessment of all body systems. Also, assessment of vital signs, oxygen saturation, cardiac output, blood gas and lab values, urine output and catheters' insertion sites, fluid intake and output. Nursing care must be

directed to reduce risks, 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)** [10]

To continue, nursing management for those ECMO patients includes providing regular physiotherapy, careful management of devices, management of distress, nutritional support, preventing stress-induced ulceration, venous thrombosis, constipation, pressure ulcers, coagulopathy, and cerebral hemorrhage. Therefore, critical care nurses should be trained on using ECMO and prevent complications. **(Warda et al, 2019)** [24]

Significance of the Study

Nurses play an important critical role in ECMO care. According to the international survey among 177 worldwide ECMO centers, the main professional roles and responsibilities of staff can manage the ECMO circuit. There were a study shows that, 59% of the centers, the ECMO specialist nurse was suggested to be mostly responsible for the bedside management of the ECMO circuit. **(Alshammari, et al, 2020)** [9]

According to the Egyptian Journal of critical care medicine, a total of 12 patients received ECMO between January 2014 and June 2015. (Age range is 13–65 years). Patients had different diagnosis and causes to connect with ECMO, beside that all patients were initially sedated and ventilated for (2–4 days). The study reports that seven patients (63.3%) were successfully separated from ECMO and survived to hospital discharge, the rest was died due to several complications. **(Abdelbary et al. 2016)** [2]

As well as critical care, specialist nurses should have good experience in early detection and prevention of complications based on adequate knowledge and practices regarding care of these patients. Therefore, the aim of the study is to assess the nurses' knowledge and practice regarding care of patients connected with extracorporeal membrane oxygenation.

Aim of the study

This study aims to assess the nurses' knowledge and practice regarding care of patients connected with Extracorporeal Membrane Oxygenation through the following objectives:

1. Assess the nurses' level of knowledge regarding care of patients connected with Extracorporeal Membrane Oxygenation.
2. Assess the nurses' level of practice regarding care of patients connected with Extracorporeal Membrane Oxygenation.

Research Questions:

1. What is the level of nurses' knowledge regarding care of patients connected with Extracorporeal Membrane Oxygenation?
2. What is the level of nurses' practice regarding care of patients connected with Extracorporeal Membrane Oxygenation?
3. Is there a relation between nurses' knowledge and practice regarding care of patients connected with Extracorporeal Membrane Oxygenation?

Subjects and Methods

Research Design:

A descriptive exploratory design was utilized in this study.

Research Setting:

The study was conducted at critical care department at Cairo University Hospitals. (Critical care unit in Qasr Al-Aini Hospital). The department consists of two floors (totally 55 beds). The first floor contains 10 beds for intensive care unit (ICU), 8 beds for intimidate care unit and coronary care unit (CCU), 11 beds for post catheterization care, and 2 beds for patient assessment. While the second floor contains 14 beds for ICU, 4 beds for isolation, 2 beds for shocked patient care, 2 beds for patient assessment, and 2 beds for ECMO.

Research Subjects:

A convenience sample of all available nurses (60 nurses) from both genders. They are working in the selected setting and dealing with patients connected with Extracorporeal Membrane Oxygenation.

Data Collection Tools:

The required data was collected through the following tools:

Tool I: Self- administered Interview Questionnaire:

It designed by the investigator based on reviewing related literature review **(Brogan, 2019) (Kapoor, 2014)** [17] 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, attendance of training courses about care of patient connected with ECMO.

- **Part II: Nurses' Knowledge Assessment Questionnaire Regarding Care of Patients Connected with ECMO:**

It developed by the investigator to assess nurses' knowledge regarding care of patient connected with ECMO which covers all the general and basic information about ECMO. It includes **5** sections:

Section 1: General knowledge about ECMO: it includes overview, history, definition, indications, goals, physiology, modes, component, complications, and management.

Section 2: Knowledge regarding occurring risks for patients connected with ECMO: it includes ECMO risks, hemodynamic risks, risks of death, bleeding risks, and haematological risks.

Section 3: Knowledge regarding the complications of ECMO: it includes mechanical complications, oxygenator complications, ECMO lines and connections complications.

Section 4: Knowledge regarding evaluation of patients connected with ECMO: it includes ECMO goals, multisystem evaluation, and ECMO lines and connection evaluation.

Section 5: Knowledge regarding the nursing role in caring patients connected with ECMO. It includes ECMO lines and connection management, multisystem management, etc.

Scoring system for nurses' knowledge assessment questionnaire regarding care of patient connected with ECMO:

This tool consisted of (65 items) with a total grade (65). One grade was given for correct answer, and zero grade for incorrect answer. Subject responses were calculated in the scoring system.

Nurses' knowledge Assessment Questionnaire Regarding Care of Patient Connected with ECMO was classified into:

- Satisfactory knowledge: if the total score was ≥ 75% equal ≥ 49 points.
- Un-satisfactory knowledge: if the total score was < 75 % equal < 49 points. **(Abo El- Ata, et al., 2019)** [5]

Tool II: Nurses' Observational Checklist Regarding Care of Patients Connected with ECMO:

It adopted from **(Kapoor, 2014)** [17] to assess nurses' practice regarding care of patient connected with ECMO. It includes of the following 4 parts:

- **Part I:** Nurses' practice regarding the pre procedure steps. It includes hand hygiene, prepare needed equipment's, etc.
- **Part II:** Nurses' practice regarding to general care of the ECMO patient. It includes management of each system in patient body system (Hemodynamic management, anticoagulation management, haematology management, respiratory management, renal management, neurological management, gastrointestinal management, nutritional management, and dermatological management).
- **Part III:** Nurses' practice regarding to special care of ECMO catheters and whole connections. (ECMO cannula and lines monitoring, ECMO circuits monitoring).
- **Part IV:** Nurses' practice regarding post procedure care steps

Scoring system for nurses' observational checklist regarding care of patients connected with ECMO:

This tool consisted of (75 items) with a total grade (75). One grade was given for done, and zero grade for not done. Subject

responses were calculated in the scoring system.

Nurses' observational checklist regarding care of patients connected with ECMO was classified in to:

- Competent level: if the total score was ≥ 75% equal ≥ 56 points.
- In-competent level: if the total score was < 75 equal < 56 points. **(Abo El- Ata, et al., 2019) [5]**

- **Tool Reliability**

The tool was measured to ensure that an assessment tool produces stable and consistent result overtime's reliability of the study tools using Alpha Cronbach test. The reliabil0ity of tool I was 0.871 and tool II was 0.869.

- **Ethical Considerations:**

An official permission to conduct the proposed study was obtained from the Scientific Research Ethics Committee. Participation in the study is voluntary and subjects were given complete full information about the study and their role before signing the informed consent. The ethical considerations were include explaining the purpose and nature of the study, stating the possibility to withdraw at any time, confidentiality of the information where it was not be accessed by any other party without taking permission of the participants. Ethics, values, culture, and beliefs were respected.

- **Pilot study:**

Pilot study was carried out on 10% (6 nurses) of sample size to test the applicability, clarity, and efficiency of the tools. The pilot study had also served to estimate the time needed for each subject to fill in the study tools. Depending on the results of the pilot study no modifications or refinements were done, and the nurses were included in the actual study sample.

- **Field work:**

Fieldwork of the study include the following:

The study conducted at one of the universities hospitals (Cairo University Hospital) at critical care department after taken approval letter from the scientific ethical committee of Faculty of Nursing at Helwan University.

This letter submitted to the department secretary to presentation in the monthly board of the department. After 2 weeks, the acceptance for data collection was done and approved.

Before data collection, there was a meeting with the head of department of nursing staff to explain the nature of data collection period and how to collect the data from participants with full respect for human right both nursing staff and patients.

The investigator introduced herself to the studied nurses and explained the purpose of the study to nurses included in the study. The actual work of this study started and completed within six months. It started from the beginning of July 2022 to the end of December 2022. It was done 2 days/ week by the investigator in the morning and afternoon shifts.

The self-administrative tool was collected from the nursing staff themselves, and the required time to collect data from each nurse for about 30-40 minutes.

Observational checklist for assessment of nurses' practice regarding care of patient connected with ECMO was collected by the investigator.

Each nurse was interviewed individually to gather the necessary data of the study. The required time to direct observation for each nurse was taken about 40 – 60 minutes.

- **Statistical Analysis:**

Upon completion of data collection through previously mentioned tools. Data entry and analysis were performed using SPSS statistical package version 26. Categorical variables were expressed as number and percentage while continuous variables were expressed as (mean ±SD). For comparison of categorical data, the $\chi 2$ - test was performed. The fisher exact test was used with small, expected numbers. Comparison of quantitative variables between the study groups was carried out

using the student t-test for independent samples to compare two groups when normally distributed. Pearson correlation was done to measure correlation between quantitative variables.

For all tests, a two-tailed p-value ≤ 0.05 was considered statistically significant, P-value ≤ 0.01 was considered highly statistically significant. While p-value> 0.05 was considered not significant.

Results:

Table (1): Shows demographic characteristics among the studied nurses. It illustrates that 41.7% of the age of the studied nurses was between 19< 30 years old with a mean age of 34.6±9.84. Also, more than two-thirds (70%) of the studied nurses were female with a male to female ratio is 0.4:1. In relation to educational level, more than two-fifths (46.7%) of them holding bachelor's degree. Considering work unit, more than three quarters (78.3%) of the studied nurses worked in ICU. Concerning years of experience in the field of nursing, about two fifths (38.3%) of them was worked for less than 5 years old with Mean ± SD =8.55± 5.40. Moreover, regarding years of experience in caring of ECMO patients, four-fifth (80%) of the studied nurses was worked in ICU less than 5 years old with Mean ± SD =4.63 ± 2.01. Finally, as regarding to attended training course, more than one third (35%) of them were attended training courses about care of patients connected with ECMO.

Figure (1): Represents total level of knowledge regarding to care of patients connected with ECMO among the studied nurses. It clarifies that more than four-fifth (88.3%) of the studied nurses had satisfactory level of knowledge regarding to care of patients connected with EMO. Moreover, the minority (11.7%) of them had un-satisfactory level of knowledge regarding care of patients connected with ECMO.

Figure (2): Represents total level of practice regarding to care of patients connected with ECMO among the studied nurses. It clarifies that more than three quarters (78.3%) of the studied nursing personnel had a competent level of practice regarding care of patients connected with ECMO. Moreover, the minority (21.7%) of them had in-competent level of practice regarding care of patients connected with ECMO.

Table (2): Show relation between total knowledge regarding to care of patients connected with ECMO and demographic characteristics among the studied nurses. It indicates that, there wasn't a statistically significant relation between total level of knowledge regarding to care of patients connected with ECMO and demographic characteristics (age, gender, educational level, working unit, years of experience in the field of nursing in nursing education, experience with ECMO device, and attended training courses) among the studied nurses.

Table (3): Show relation between total practice regarding to care of patients connected with ECMO and demographic characteristics among the studied nurses. It indicates that, there was a highly statistically significant relation between total level of practice regarding to care of patients connected with ECMO and demographic characteristics (age, educational level, years of experience in the field of nursing in nursing education, experience with ECMO device, and attended training courses about ECMO) among the studied nurses at P value ranged from 0.000 to 0.04. while there wasn't statistically significant relation between total level of practice regarding care of patients connected with ECMO and demographic characteristics (gender, workplace).

Table (4): Illustrates correlational matrix between knowledge and practice regarding to care of patients connected with ECMO among the studied nurses. It indicates that there was a positive strong highly statistically significant correlation between knowledge and practice dimension (pre-care, general pt.'s care and special care of ECMO device). Additionally, it clarifies that, there was a positive strong highly statistically significant correlation between total knowledge and practice regarding to care of

patients connected with ECMO among the studied nurses.

Figure (3): Illustrates scatter dot between knowledge and practice regarding to care of patients connected with ECMO among the studied nurses. It clarifies that, there was a positive strong highly statistically significant correlation between total knowledge and practice regarding to care of patients connected with ECMO among the studied nurses at r= 0.966 & P= 0.000).

Table (1): Frequency and percentage distribution of demographic characteristics of the studied nurses (n= 60)

Items		No.	%
Age (year)	▪ 19 < 30 Yrs.	25	41.7
	▪ 30 < 40 Yrs.	17	28.3
	▪ 41 < 50 Yrs.	14	23.3
	▪ ≥ 50 Yrs.	4	6.7
	▪ **Mean ± SD**	**34.6±9.84**	
Gender	▪ Male	18	30.0
	▪ Female	42	70.0
	▪ **Male to female ratio**	**0.4:1**	
Educational level	▪ Diploma	16	26.7
	▪ Technical Nursing Institute	16	26.7
	▪ Bachelor's Degree	28	46.7
Work unit	▪ ICU	47	78.3
	▪ CCU	13	21.7
Years of experience in the field of nursing	▪ < 5	23	38.3
	▪ 5 < 10	22	36.7
	▪ ≥ 10	15	25.0
	▪ **Mean ± SD**	**8.55± 5.40**	
Experience in caring of ECMO patients	▪ < 5	48	80.0
	▪ 5 < 10	12	20.0
	▪ **Mean ± SD**	**4.63 ± 2.01**	
Attended training courses about ECMO	▪ **Yes**	21	35.0
	▪ **No**	39	65.0

Figure (1): Percentage distribution of total level of knowledge regarding to care of patients connected with ECMO among the studied nurse (n= 60)

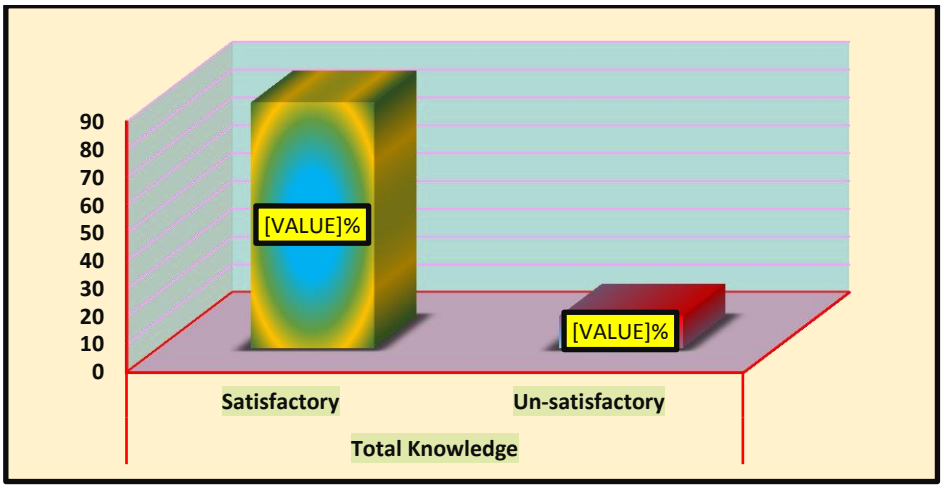


Figure (2): Percentage distribution of total level of practice regarding to care of patients connected with ECMO among the studied nurses (n= 60)

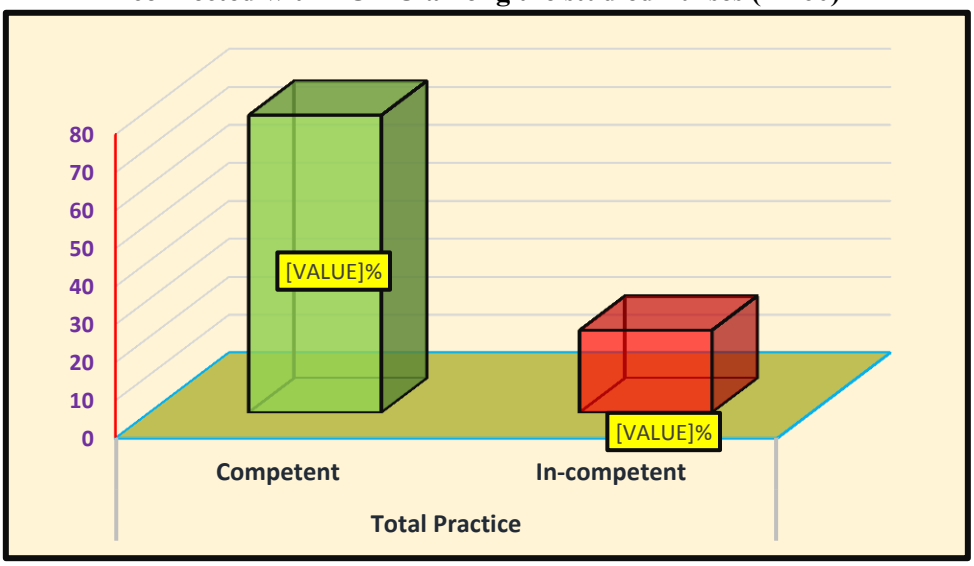


Table (2): Relation between total knowledge regarding to care of patients connected with ECMO and demographic characteristics among the studied nurses (n= 60)

Items		Total knowledge				χ^2	P-Value
		Un-Satisfactory		Satisfactory			
		7	11.7	53	88.3		
		N	%	N	%		
Age	▪ 19< 30	5	8.3	20	33.3	4.89	0.179
	▪ 30 < 40	0	0.0	17	28.3		
	▪ 41 < 50	1	1.7	13	21.7		
	▪ ≥ 50	1	1.7	3	5.0		
Gender	▪ Male	1	1.7	17	28.3	0.93	FET 0.314
	▪ Female	6	10.0	36	60.0		
Educational level	▪ Diploma	4	6.7	12	20.0	4.89	0.086
	▪ Technical	0	0.0	16	26.7		
	▪ Bachelor	3	5.0	25	41.7		
Work unit	▪ ICU	6	10.0	41	68.3	0.254	FET 0.524
	▪ Catheter Unit	1	1.7	12	20.0		
Years of experience in the field of nursing	▪ < 5	2	3.3	21	35.0	4.55	0.103
	▪ 5 < 10	1	1.7	21	35.0		

	▪ ≥ 10	4	6.7	11	18.3		
Experience with ECMO device	▪ < 5	7	11.7	41	68.3	1.98	FET 0.191
	▪ 5 < 10	0	0.0	12	20.0		
Attended training course about ECMO	▪ Yes	4	6.7	17	28.3	1.70	FET 0.186
	▪ No	3	5.0	36	60.0		

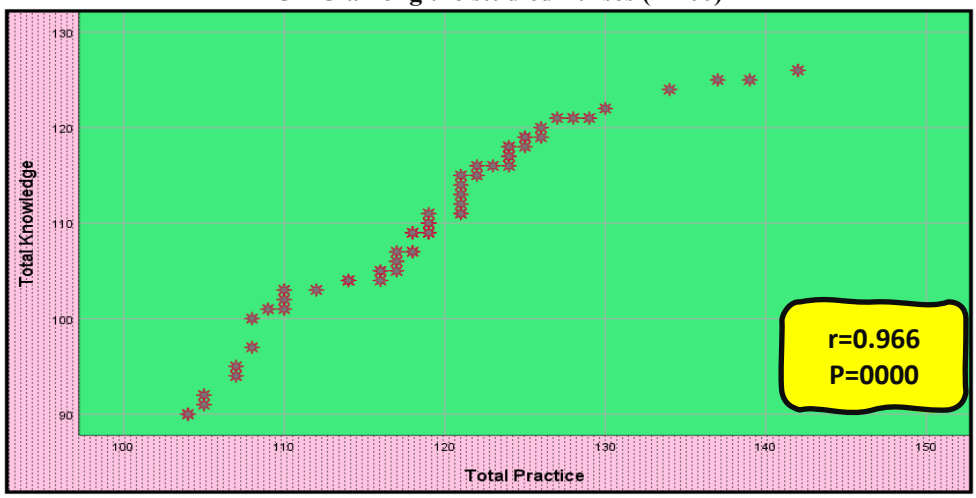
Table (3): Relations between total practice regarding to care of patients connected with ECMO and demographic characteristics among the studied nurses (n= 60)

Items		**Total Practice**				**χ^2**	**P-Value**
		In- Competent		**Competent**			
		13	**21.7**	**47**	**78.3**		
		N	**%**	**N**	**%**		
Age	▪ 19 < 30	11	18.3	14	23.3	13.81	0.003
	▪ 30 < 40	0	0.0	17	28.3		
	▪ 41 < 50	1	1.7	13	21.7		
	▪ ≥ 50	1	1.7	3	5.0		
Gender	▪ Male	2	3.3	16	26.7	1.68	FET 0.170
	▪ Female	11	18.3	31	51.7		
Educational level	▪ Diploma	10	16.7	6	10.0	22.12	0.000
	▪ Technical	0	0.0	16	26.7		
	▪ Bachelor	3	5.0	25	41.7		
Work Unit	▪ ICU	10	16.7	37	61.7	0.01	FET 0.576
	▪ Catheter Unit	3	5.0	10	16.7		
Years of experience in the field of nursing	▪ < 5	8	13.3	15	25.0	6.35	0.042
	▪ 5 < 10	1	1.7	21	35.0		
	▪ ≥ 10	4	6.7	11	18.3		
Experience with ECMO device	▪ < 5	13	21.7	35	58.3	4.14	FET 0.037
	▪ 5 < 10	0	0.0	12	20.0		
Attended training course about ECMO	▪ Yes	10	16.7	11	18.3	12.82	FET 0.001
	▪ No	3	5.0	36	60.0		

Table (4) Correlational matrix between total knowledge and practice regarding to care of patients connected with ECMO among the studied nurses (n= 60)

Total Knowledge		**Total Practice**		
		Pre-care	**General Pt's care**	**Special Care of ECMO device**
▪ General information	**R**	0.934	0.939	0.982
	P	0.000**	0.000**	0.000**
▪ Risks	**R**	0.913	0.949	0.976
	P	0.000**	0.000**	0.000**
▪ Complications	**R**	0.948	0.951	0.974
	P	0.000**	0.000**	0.000**
▪ Evaluation	**R**	0.947	0.958	0.978
	P	0.000**	0.000**	0.000**
▪ Nursing role	**R**	0.947	0.945	0984
	P	0.000**	0.000**	0.000**
▪ Total	**R**	**0.966**		
	P	**0.000****		

Figure (3) Scatter dot between total knowledge and practice regarding to care of patients connected with ECMO among the studied nurses (n= 60)



Discussion

In relation to demographic characteristics of the studied nurses, the current study revealed that, more than one-thirds of the studied nurses their age group were between 19-30 years and their mean was (34.6±9.84). This study in disagreement with **Abdelrahman et al., (2020)** [3] who conducted a study titled "Assessment of Nurses' Knowledge and Practices Regarding Care of Patients with Diabetic Coma". Who stated that the majority of the studied sample were young age ranged between 19-30 years. According to the researcher point of view the golden age for gain knowledge and experience is during young adulthood. In this period the learner became mature enough to learning and developing the practical skills.

The present study mentioned that, more than two- thirds of the studied nurses were female. This finding was in line with **Mahmoud, (2018)** [20] who carried out "Nurses' Performance Regarding Nasogastric Tube Feeding Among Critically Ill Patients" and presented that about two-thirds of the studied nurses were female. According to the researcher point of view, this is related to the setting of the study because it is associated to government; and most of the nurses are appointed in the government sector.

The current study reported that, about half of the studied nurses had bachelor's degree in nursing. This finding in disagreement with **Alshammari, (2020)** [9], who conducted study titled "Nurses' perception of their role in extracorporeal membrane oxygenation care: A qualitative assessment" who reported that more than two-third of the studied nurses had bachelor's degree in nursing.

The current study revealed that, the majority of the studied nurses worked in ICU. While the minority of them working in Catheter unit. This finding agrees with **ELSO guidelines**, that the ECMO centers should be in tertiary centers with a tertiary level as Neonatal Intensive Care Unit (NICU), Pediatric Intensive Care Unit (PICU) and/or Adult Intensive Care Unit (AICU). **(Bartlett, ELSO Guidelines for ECMO Centers 2014)** [15].

According to the investigator's point of view, the selected research study followed the ELSO guidelines to facilitate the work environment among all medical staff and improve the quality of care that provided to the ECMO patient.

The present study revealed that, more than one- third of the studied nurses had years of experience in nursing (<5) years. This study disagrees with **Elsayed, (2022)** [12] who conducted study titled "Assessment of Nurses' Knowledge and Practice Regarding Antiarrhythmic Medication at Critical Care Units" that show more than two- third of the studied nurses' had years of experience in nursing (<5) years.

The current study stated that, about two- thirds of the studied nurses didn't attend training courses regarding care of patient connected with ECMO. This finding matched with **Ahmed et al, (2021)** [6] who conducted study titled "Assessment of Nurses' Knowledge and Practice Regarding Care for Patients with Spinal Cord Injury in the Critical Care Unit" who stated that about two- third of the studied nurses didn't attend any training courses.

Regarding the total level of nurses' knowledge regarding to care of patients connected with ECMO, the finding showed that the majority of the studied nurses had satisfactory level of knowledge. This finding similar to **Kheder & Mohammed, (2019)** [18] who conducted a study titled "Nurses' Knowledge toward Care of Unconscious Adult Patients at Teaching Hospitals in Al-Hilla City" and reported that all studied nurses had enough knowledge.

Additionally, this finding is consistent with **Mohammed & Ebrahem, (2022)** [21]**,** who conducted a study about "Relationship between Critical Care Nurses' Knowledge and Clinical Decision-Making Role in Managing Mechanically Ventilated Patients" the result of study revealed that the majority of the studied sample had a satisfactory level of knowledge about caring for patients on mechanical ventilation, more than two thirds of the studied sample had moderate insight of decision-making role.

Besides, this finding is matched with **Ahmed, (2021)** [6] who conducted a study titled "Assessment of Nurses' Knowledge and Practice Regarding Care for Patients with Spinal Cord Injury in the Critical Care Unit" the result showed that more than half of the studied nurses had satisfactory total knowledge regarding caring for patients with spinal cord injury in critical care unit.

On the other hand, this finding is disagreed with **Ismail, et al (2018)** [16]**,** who conducted as study titled "Assessment of Critical Care Nurse's Knowledge and Practices Regarding Care of Patients Receiving Total Parenteral Nutrition" that reported that the majority of the studied sample had unsatisfactory level of knowledge.

Regarding the total level of nurses practice regarding care of patients connected with ECMO, the current study revealed that the majority of studied nurses had a competent level of practice. This finding is incongruent with **Ahmed, (2021)** [6] who conducted a study titled "Assessment of Nurses' Knowledge and Practice Regarding Care for Patients with Spinal Cord Injury in the Critical Care Unit" the result showed that showed more than half of the studied nurses had an unsatisfactory level of total practice regarding caring for patients with spinal cord injury in critical care unit.

According to the researcher point of view that the research setting of this study, provides an ECMO training course for medical staff including nurses, who already worked in the ICU. That has a great positive impact on nurses' knowledge and their practice.

The course based on ELSO guidelines and focus on simulation-based learning. The duration of course about 2 days including theoretical sessions and practical sessions under supervision professor of critical care medicine, at Cairo university and he is president of SWAAC ELSO in Egypt.

The finding of is agrees with **Kim et al., (2018)** [19]**,** who conducted a study about "The effect of an improvement of experience and training in extracorporeal membrane oxygenation management on clinical outcomes" this shows there were an improvement in experiences and training based on clinical patient outcomes and enhance to decrease in mortality rate among patients.

Moreover, this agrees with **Ahmed et al., (2019)** [7]**,** who conducted a study entitled "Effect of an Educational Program on Nurses' Knowledge and Practice Regarding Defibrillation and Cardioversion" The study results show nurses' level of knowledge and practice in caring of patients was unsatisfactory before the program and significantly improved immediately post program.

One of the greater benefits of the ECMO training courses for nurses are each nurses known his/her role in caring patients with ECMO that based to the ELSO guidelines. This agrees with **Alshammari et al., (2020)** [9]**,** who conducted a study about "Nurses' perception of their role in

extracorporeal membrane oxygenation care" the result shows it was discovered that the role of a nurse was varied, difficult, and entailed handling several tasks and responsibilities.

The nurses' performance was helped by their teamwork with other healthcare professionals. The training they had received and the time they had spent delivering extracorporeal membrane oxygenation care were the key factors that nurses believed contributed to their perception of their own competence in their roles.

Moreover, this consistent with **Said et al., (2022) [22],** who conducted a study titled "Development of a Standardized Assessment of Simulation-based Extracorporeal Membrane Oxygenation Educational Courses". The study reported that pre course of studied nurses was half level of satisfaction and post course the level was reach to a high level of satisfaction.

Concerning relation between nurses' knowledge and demographic characteristic of the studied nurses, the current study mentioned that there wasn't a statistically significant relation between total knowledge regarding to care of patients connected with ECMO and demographic characteristics (age, gender, educational level, working unit, years of experience in the field of nursing in nursing education, experience with ECMO device, and attended training courses) among the studied nurses.

This finding is matched with **Abdelrahman., et al., (2020) [3],** who conducted a study titled "Assessment of Nurses' Knowledge and Practices Regarding Care of Patients with Diabetic Coma" the study finding illustrate there is no significance differences relation between knowledge and demographic characteristics among the studied nurses.

Concerning relation between nurses' practice and demographic characteristic of the studied nurses, the current study mentioned that there was a highly statistically significant relation between total practice regarding to care of patients connected with ECMO and demographic characteristics.

This finding agrees with **Warda et al., (2019) [24]** who conducted a study titled "Effect of Educational Program About Care of Patients Connected to Extracorporeal Membrane Oxygenation (ECMO) on Nurses Knowledge and Practices" The result showed there was a highly statistically significant relation between total level of practice and demographic characteristics among the studied nurses.

This finding is dissimilar with **Abo Aita et al., (2022) [4],** who conducted a study titled "Assessment of Critical Care Nurses' Knowledge and Practice Regarding Care of Patients Undergoing Total Parenteral Nutrition" the study result show that there was no statistically significant relation between total level of nurses' practices and their demographic characteristics.

Concerning correlation between the studied variables, the current study mentioned that there was a positive strong highly statistically significant correlation between nurses' knowledge and their practice. Additionally, there was a positive strong highly statistically significant correlation between total knowledge and practice regarding to care of patients connected with ECMO.

This finding is matched with **Ahmed, (2021) [21]** who conducted a study titled "Assessment of Nurses' Knowledge and Practice Regarding Care for Patients with Spinal Cord Injury in the Critical Care Unit" the result showed that there was statically significant relation between nurses' knowledge and their level of practice regarding caring for patients with spinal cord injury.

The same result reported by **Essa, et al., (2019) [14],** in the research titled "Assessment of the Nurses' Knowledge during Caring for Hemodialysis Patients" the result revealed there was a correlation between the nurse's level of knowledge and their performance.

To contract, this finding agrees with the study conducted by **Sobh et al., (2019) [23]** about "Knowledge and Practice of Staff Nurses Related to Health Care Waste Management" The result pointed a statistically significant correlation between nurses' knowledge and their practice.

Moreover, the finding is agreed with **Abdel-Aal et al., (2020) [1]** who reported in a study conducted about "Assessing Nurses'

Knowledge and Performance Regarding Shift Report Handover" There were significant positive correlation between knowledge level and performance level.

Conclusion

Based on the study findings of the present study, it can be concluded that: the majority of the studied nurses had a satisfactory level of knowledge regarding care of patients connected with ECMO and the majority of studied nurses had a competent level of practice regarding care of patients connected with ECMO.

Moreover, the current study revealed that there were highly statistically significant positive correlations between the studied nurses' total knowledge and their practice regarding care of patients connected to ECMO.

Recommendation

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

Recommendations for further studies:

- Replication of the study on larger probability sample at different geographical locations for data generalizability.

Recommendations for practice:

- Continuous training courses should be conducted for nurses to improve their knowledge and practice regarding care of patients with ECMO.
- Provide workshop and seminar-based learning for nurses to increase their performance regarding care of patients with ECMO.
- Developing a simplified illustrated and comprehensive booklet for improving nurses performance regarding care of patients connected to ECMO.

Recommendations for education:

- Providing an ECMO program in nurses student curriculum in school/ faculty.

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