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The Effect of Rewarming Maneuvers on the Severity of Hypothermia among Critically Ill Patients

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Abstract

Background: Rewarming maneuvers effectively reduce hypothermia severity in critically ill patients. However, some factors like diabetes, low body weight, and low Glasgow Coma Scale scores can be affected by these interventions. Tailored rewarming approaches can improve patient outcomes. **Aim:** Evaluates the effect of rewarming maneuvers on the severity of hypothermia among critically ill patients. **Design:** A quasi-experimental research design was utilized in this study. **Setting:** This study was conducted in the intensive care unit at Ain Shams University specialized hospital in Cairo. **Subjects:** Purposive sample of 60 adult patients' diagnosed with hypothermia. **Tools of data collection:** Tools were (I) Patient general assessment questionnaire consists of two main parts; patient personal data, and the patient assessment and (II) The rewarming manoeuvers **Results:** less than one-fifth of nurses had efficient practices regarding rewarming manoeuvers pre-intervention, which improved to two-thirds at post-intervention. In addition, about one-third of standard nurses had efficient use of rewarming manoeuvers at pre-intervention, which improved to about two-thirds at post-intervention. **Conclusion:** there was a highly statistically significant negative correlation between total practices and patient general assessment with a large effect size of rewarming manoeuvers at post-intervention. **Recommendations:** Applying workshops and seminars to keep healthcare professionals updated on the latest research and best practices in hypothermia management.

Keywords: Critically Ill Patients, Hypothermia, Nursing intervention, Rewarming maneuvers.

Introduction

Hypothermia is a condition characterized by abnormally low body temperature and poses a significant threat to critically ill patients. Defined as a core body temperature below 35°C (95°F), hypothermia can progress through distinct stages, each associated with increasing physiological impairment. The mechanisms of hypothermia involve a complex interplay of heat loss and the body's compensatory responses **(Rout et al. 2020).** Also, the symptoms of hypothermia vary depending on the severity. In mild hypothermia, individuals may experience shivering, fatigue, and confusion. As the condition progresses to moderate hypothermia, shivering may stop, and confusion can increase. Severe hypothermia can lead to a loss of consciousness, weak pulse, shallow breathing, and even cardiac arrest. Management of hypothermia depends on the degree of it **(Chung et al., 2023).**

Risk factors include age: Newborns and older adults have less developed or less efficient thermoregulatory systems, being more vulnerable to temperature extremes. Dehydration can impair blood flow and sweating efficiency, hindering the body's ability to lose heat or maintain core temperature. Different types of shock can reduce blood flow and impair heat delivery to vital organs **(Tan et al., 2024).** As regards the risk of hypothermia can have a significant impact on critically ill patients. Critically ill patients often have pre-existing health conditions. Hypothermia can further exacerbate these conditions and complicate their management. The potential dangers associated with hypothermia include impaired organ function, expressed as core temperature drops and various bodily functions becoming sluggish **(Gocoł et al., 2021).**

Managing hypothermia in the intensive care unit (ICU) involves several steps to gradually rewarm the patient: This can include the use of warmed intravenous fluids, heating blankets, and forced-air warming devices. Careful monitoring of the patient's vital signs is crucial to avoid complications such as arrhythmias

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and rewarming shock: Several factors can influence the development and severity of hypothermia in ICU patients. These include the patient's age, underlying medical conditions, medications, and the duration of exposure to cold environments. Elderly patients and those with compromised immune systems are particularly vulnerable to hypothermia **(Sugiyama et al., 2024).**

Rewarming is the process of increasing the body temperature in hypothermic patients to restore normal physiological function. In an ICU setting, rewarming manoeuvers refer to a variety of methods used to raise the core body temperature of a patient with hypothermia. These manoeuvers aim to achieve a safe and controlled increase in temperature to minimize complications and improve patient outcomes **(Deakin et al. 2020).** Several rewarming techniques are available to treat hypothermia, each with its advantages and drawbacks. Passive rewarming involves removing wet clothing and providing warm blankets, but it is generally slow and ineffective in severe hypothermia. Active external rewarming utilizes warm air or water to increase core temperature, but it can cause peripheral vasodilation and potentially worsen hypothermia **(Nilsen et al. 2021).**

Active internal rewarming techniques, such as warmed intravenous fluids and hemodialysis, are more rapid but require specialized equipment and expertise. Extracorporeal membrane oxygenation (ECMO) can be used in severe cases, providing both oxygenation and rewarming, but it carries significant risks. The choice of rewarming method depends on the severity of hypothermia, the patient's overall condition, and available resources **(Dankiewicz et al. 2021).** Beyond immediate patient benefits, impacting broader healthcare outcomes. By optimizing rewarming strategies, costs can be reduced, public health initiatives can be informed, global healthcare standards can be elevated, and educational opportunities for healthcare professionals can be enriched, ultimately improving patient care and resource allocation **(Liu and Qi, 2021).**

So, developing a program about the effect of rewarming maneuvers on the severity of hypothermia among critically ill patients aims to investigate the impact of different rewarming maneuvers on the severity of hypothermia in critically ill patients. By following a structured research program and addressing the outlined components, this study can contribute significantly to the understanding and management of hypothermia in critically ill patients **(Nilsen et al. 2021).** The program involves a comprehensive study of various rewarming techniques to determine their impact on patient survival, organ function, and overall recovery. The researcher will also examine the role of nurses in implementing and monitoring these rewarming strategies, aiming to optimize patient care and enhance the nursing profession's knowledge in managing hypothermia **(Mydske & Thomassen, 2020).**

Therefore, nurses play a crucial role in identifying risk factors for hypothermia, recognizing the different stages, and implementing preventive measures in critically ill patients. Nurses conduct comprehensive assessments of critically ill patients, including reviewing past medical records for patients' conditions. Monitoring medications that might interfere with thermoregulation, such as sedatives or vasodilators. Assessing for malnutrition can decrease a patient's ability to generate heat. Being aware of the ambient temperature in the patient's surroundings and ensuring adequate insulation **(Masè et al., 2021).**

Significance of the study

According to the World Health Organization (WHO) in 2021, the death probability for patients with hypothermia is 2.06 times higher than for those without. Moreover, 75% of deaths in ventilated patients had been hypothermia as well, in 10000 non-SARS-CoV-2 patients with sepsis 47% of the deaths caused was hypothermia. Mortality and morbidity risk caused by hypothermia depends on the severity of the degree of it. The mortality rate of hypothermia in critically ill patients is higher than in patients who have other diseases **(Fatteh et al., 2021).**

According to a systematic review and meta-analysis of 37 studies published in the journal Critical Care Medicine in 2019, hypothermia was associated with a 4.4-fold increased risk of mortality in critically ill patients, which ranged from 25% to 57%, depending on the severity of the hypothermia. Additionally, hypothermia is associated with an increased risk of infection, coagulopathy, and metabolic acidosis, all of which can have a significant impact on patient outcomes **(Zafren et al., 2023).**

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Aim of the study

Evaluates the effect of rewarming maneuvers on the severity of hypothermia among critically ill patients, through the following objectives:

1.Assess nurse's knowledge regarding hypothermia.
2.Assess nurses' knowledge regarding rewarming manoeuvers.
3.Assess nurses' practice regarding rewarming manoeuvers.
4.Evaluates the effect of rewarming manoeuvers on the severity of hypothermia among critically ill patients.

Research hypothesis: -

The implementation of rewarming manoeuvers will have a positive effect on the severity level of hypothermia among critically ill patients.

Subject and methods

Research design: A quasi-experimental research design was utilized in this study.

A quasi-experimental research design will be used to conduct this study. This methodological approach was used to evaluate causal relationships when random assignment of participants to treatment and control groups was not feasible due to ethical or practical constraints. Unlike true experiments, quasi-experiments rely on pre-existing groups or non-random criteria for group allocation, which may introduce confounding variables. However, they still involve manipulation of an independent variable and often include control mechanisms such as pretest-posttest comparisons, nonequivalent group designs, or regression discontinuity to strengthen internal validity **(Cook & Shadish, 2023).**

Setting: The study was directed at the intensive care unit at Ain Shams University specialized hospital in Cairo, Egypt. The ICU is located on the second floor and consists of 48 ICU beds.

In addition, the ICU is divided into A, B, and C, ICUs for general cases. Besides D ICU which is called chest ICU, and intermediate called bone marrow ICU. Furthermore, the number of nurses was distributed as; the A ICU (15 nurses), the B ICU (15 nurses), the CICU (15 nurses), the D ICU (5 nurses), and the bone marrow ICU (10 nurses).

Sampling: Purposive sample of 60 adult patients' diagnosed with hypothermia, available at the time of the study.

Tools for data collection:

Tool (I): Patient General Assessment questionnaire; it was adopted from **(Stöhr et al., 2021;** and **Tong et al., 2020),** and this tool consisted of two main parts;

Part I: Patient personal data involved patient code, age, gender, and marital status, level of education, occupation, residence, and length of ICU stays, body mass index, weight, and height.

Part II: Patient General Assessment; this part was used to collect patient data and consisted of 5 sections.

- **Section I: Patient clinical data;** this section included; patient present history, comorbidities, surgical health history, nutritional status, and connected devices.
- **Section II: Hemodynamic monitoring;** this section included (8) items. Vital signs measuring included (PB, HR, Temp. RR, CVP, and urine output), Glasgow Coma Scale, Richmond agitation scale,
- **Section III: Laboratory Investigations;** this section included (6) items including, ABG, CBC, coagulation profile, electrolytes, renal and liver functions.
- **Section IV: Medications administration;** this section included (5) items, antibiotic, diuretic, anticoagulation, vitamin supplement, sedation.
- **Section IV: Patient outcomes and complications;** this section included (16) items (Hypotension, hypertension, shivering, hypovolemia with cold diuresis, hypomagnesaemia, metabolic acidosis,

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hypokalemia, hyperglycemia, hypoglycemia, bradycardia or cardiac arrhythmia, loss of consciousness or coma, pneumonia, pulmonary edema, respiratory acidosis, decreased gastrointestinal motility, skin breakdown or pressure sores, and death). Which collected from retrospective previous record before starting the study and compared by the same sample of existing records throughout study application.

The patient assessment questionnaire consisted of (35 items) which were scored 70 grades as 2 degrees for within normal value and 1 abnormal value. The total assessment score was summed and calculated as follows:

- ≥ 70% considered efficient practices which equaled (≥ 49).
- < 70 considered inefficient practices which equaled (< 49).

Tool (II): Part II: Rewarming manoeuvers, it was constructed and adapted by the researchers based on **Mahmoud et al., (2018) and Smith, (2023),** included (11) items. This part includes warming environment, warm intravenous fluid and blood product, warming blankets, diet, sweet drinks, ensure dry, cover close wound, humidified gases and ventilation, radiant warmer, achieve movement, and others types of rewarming.

The scoring system:-

It used to assess the using of rewarming manoeuvers, by using 2 degrees as (2) done, (1) not done, consisted of (11 items) with a total score of (22). The total grades of items were summed up, converted into a percentage score, and classified into three levels as the following:-

- < 75 %, considered incompetent practice and inefficiently used (≤ 16.5).
- ≥ 75% considered competent practice and efficiently used (≥16.5).

Validity and reliability:

Validity:

Validity of the tools tested by a group of five experts specific to medical-surgical nursing, from various two academies, that is to say; (One lecturer, critical care nursing, Faculty of Nursing, Helwan University), (Two Professors, medical-surgical, Faculty of Nursing, Cairo University), Two assistant professors, critical care nursing, Faculty of Nursing, Helwan University), assessed the content validity, and the little needed modifications were done.

Reliability:

Cronbach's Alpha was used to determine the internal reliability of the tool. Reliability of the tools was tested to determine the extent to which the questionnaire items are related to each other and the result was (0.719 and 0.759) for patient outcome questionnaire and rewarming manoeuvres, respectively.

Code of ethics and legal considerations:

The research authorization got from the Faculty of Nursing Ethical Committee of Helwan University before offset the training, an authorization got from the Hospital Administrators and Directors of Nurses at Ain Shams University Hospitals. In addition, approval was obtained from the heads of the ICU department. Participation in the study was voluntary, and subjects were given complete full information about the study, and they had the right to withdraw from the study at any time without any reason. They also were assured that anonymity and confidentiality of their information were guaranteed, as well the gathered data were used for research purposes only and would not be accessed by any other party without taking permission of the participants. Ethics, values, culture, and beliefs were respected.

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Pilot study

The researcher performed the pilot study to evaluate the study instruments' clarity, relevance, and applicability, as well as to identify any potential challenges in data collection, after jury experts examined the data collection methods. The pilot study was conducted on 10% of the total sample size, which consisted of 6 patients. It also aided in estimating the time required to complete the questionnaire instruments, which took between 20 and 30 minutes. There was no modification. So, the subjects were participated in the pilot study, were included in the total study sample.

Field work:

- The purpose of the study was explained prior to answering the questionnaire. The patients' personal data, practical rewarming maneuvers and patient assessment questionnaire were used where the nurses rewarming the patients in the ICU to ensure the maximal realistic observations of nurses' practice, patients' real data and minimize the possibility of bias. Direct observation was conducted by the investigator to appraise nurses' practice level during rewarming maneuvers.
- The tools were used on the first, third, fifth, and seventh days, which corresponds to the morning and afternoon shifts. On Sunday, Tuesday, Thursday, and Saturday—four days a week, it was conducted according to a set timetable. In relation to hypothermia, the researcher collected and documented laboratory data, obtained the patient's overall assessment, including the patient's neurological and haemodynamic status, and performed an ECG. The investigator completed the rewarming maneuvers sheet for by watching the nurses while performing rewarming procedures in the intensive care unit. The allotted time to complete the sheet was roughly 10 to 15 minutes.
- The researcher created rewarming manoeuvres intervention's content based on the preliminary evaluation, the rewarming manoeuvres' content was created specifically for the nurses and written in basic Arabic. This program booklet served as a reference and guide for intensive care unit nurses, covering the knowledge and practice associated with rewarming manoeuvres.
- The rewarming manoeuvers intervention was given to nurses to provide the ICU nurses with cognitive knowledge, psychomotor skills and build a firm foundation for nurses' knowledge and practice regarding rewarming manoeuvers. The rewarming manoeuvers intervention was delivered throughout 24 weeks, each week involved 1 session and 1 group per day, and every session lasted about 90 min. the total number of groups was 3 groups (20 nurses for each group). Each nurse of 60 nurses (study group) took 8 sessions. Each teaching session lasted for 90 min.; 8 sessions × 3 groups = 24 sessions. 24 session's × 1.5 hours = 36 hours for the entire study group.
- Practical sessions (were held using real items, demonstrations, and redemonstration). From February 2024 until the end of May 2024, the implementation phase of the program spanned three months. It took two sessions to finish (each one was 90 minutes). Eight sessions made up the rewarming methods intervention: six for the theoretical component and two for the practical component.
- The study tool was used to evaluate pre and post rewarming manoeuvers implementation and efficiency and patients' general assessment was filled 4 times throughout implementation, at the 1st, 3rd, 5th, and 7th day of rewarming manoeuvers intervention. The data collection documented through 6 months started in December 2023 to the end of May 2024.

Statistical analysis:

Data entry and analysis were performed using SPSS statistical package version (25). Categorical variables were expressed as numbers and percentages while continuous variables were expressed as (mean

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±SD). Chi-square (x2), Independent Samples t-test, and Paired t-test used to compare were used to test the association between row and column variables of qualitative data. ANOVA, (F) test was used to compare the mean in normally distributed quantitative variables in more than two groups**.** Pearson correlation was done to measure the correlation between quantitative variables. Probability (P-value) was considered significant as (Insignificant p >0.05, significant p <0.05, and highly significant p <0.01).

Results

Table (1): Frequency and distribution of the studied patients' personal data (60)

Patients' socio-demographic characteristics		N	%
Age	20-less than 30 years	0	0
	40-50 years	6	10
	≥ 50 years old.	54	**90**
	Mean (SD) 60.84 ± 8.72		
Gender	Female	28	46.7
	Male	32	**53.3**
Marital status	Single	10	16.7
	Married	26	**43.3**
	Divorced	10	16.7
	Widow	14	23.3
Level of education	Not read and write	9	15.0
	Read and write	5	8.3
	Basic education	21	**35.0**
	Secondary education	15	25.0
	University education.	10	16.7
Occupation	Not working	25	16.7
	Employee	35	41.7
	Housewife	36	**58.3**
Residence	Urban	24	**60.0**
	Rural	25	40.0
Length of ICU stays	Min	7	
	Max	14	
	Mean (SD) 10.90±2.02		
Nutrition status	Underweight (< 18.5	**0**	**0**
	Normal (18.5 - 24.9).	36	60
	Overweight (25 29.9).	20	**33.3**
	Obese (30 or above)	4	6.67
Body mass index (BMI)	**Mean ± SD**	22.77 ± 2.46	
Weight	**Mean ± SD**	75.00 ± 7.41	
Height	**Mean ± SD**	166.03 ± 6.77	

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Table (1) shows that shows that 90% of studied patients ages ≥ 50 years old with a mean (SD) of 60.84 ± 8.72 and 53.3% of studied patients are males. Regarding marital status, 43.3% of them are married. In addition, 35.0% of them have basic education. Also, 58.3% are housewives, and 60.0% live in urban areas. Additionally, 33.3% of critically ill patients were classified as overweight regarding nutritional status, with a mean of BMI 28.77 ± 3.66. The mean weight was 80.00 ± 15.41 kg, and the mean height was 166.03 ± 6.77 cm.

Table (2): Frequency and distribution of patient's current diagnosis, patient's comorbidities and patient's surgical health history (n=60).

Patent clinical data	Frequency	Percent
Patients present history		
Post-surgery	20	33.3
Heart failure	6	10.0
Infection	30	**50.0**
Burn	10	16.7
Cardiac angina	8	13.3
Respiratory distress	9	15.0
Post-stroke	5	8.3
Allergy	30	**50.0**
Current diagnosis:		
Pneumonia	14	23.3
Heart failure	10	16.7
COPD	6	10.0
Sepsis	30	**50.0**
Septic shock	10	16.7
Respiratory failure	14	23.3
Comorbidities		
Asthma	9	15.0
COPD	4	6.7
Diabetes	28	**46.7**
Obesity	5	8.3
Hypertension	22	**36.7**

Patients may have more than one condition

Table (2) shows that 50% of patients have an infection and an allergy. Also, diabetes and hypertension was the most common comorbidity (46.7% & 36.7%), while 20.0% had no comorbidities.

Table (3) Percentage distribution of connected devices among critically ill patients (n= 60).

Connected devices		N	%
Feeding connection?	Nasogastric tube.	28	**46.7**
	Jejunostomy.	0	0
Artificial airway?	Oropharyngeal Airway	15	25.0
	Nasal Cannula.	21	**35.0**
	Oxygen mask.	7	11.7
	Endotracheal tube.	11	18.3
Chest tube?	Yes	30	50.0
	No	30	50.0
Surgical drain?	Yes	26	43.3
	No	34	**56.7**

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Urinary Catheter	Yes	50	**83.3**
	No	10	16.7
Mechanical ventilator	Yes	46	**76.7**
	No	14	23.3
IV connections	Cannula.	36	**60.0**
	CVC.	24	40.0
	Permcath.	0	0

Patients may have more than one devices

Table (3) shows that 46.7% of patients had nasogastric tubes for feeding, while 35.0% used nasal cannulas as artificial airways. Chest tubes and urinary catheters were used in 50.0% and 83.3% of patients, respectively. Mechanical ventilators were connected to 76.7% of patients, and 60.0% had cannulas for vascular access.

Table (4): Frequency and distribution of the studied nurses' practices regarding rewarming maneuvers of hypothermic patient among critically ill patients pre – post intervention (n = 60).

Rewarming device	**Pre-**								**Post-**								***T***	***P***
	Used				**Effective**				**Used**				**Effective**					
	Yes		**No**		**Yes**		**No**		**Yes**		**No**		**Yes**		**No**			
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		
Warming environment and clothing	13	**21.7**	47	78.3	6	**46.2**	7	53.8	48	**80.0**	12	20.0	43	**90**	5	10	.241	.021*
Warming IV fluids and blood.	18	**30.0**	42	70.0	11	**61.1**	7	38.9	51	**85.0**	9	15.0	46	**90**	5	10	1.762	.053
Warming blankets.	29	**48.3**	31	51.7	25	**86.2**	4	13.8	53	**88.3**	7	11.7	50	**94**	3	6	4.459	.000**
Warming diet.	0	0.0	60	100.0	0	0.0	0	0.0	50	83.3	10	16.7	39	78	11	22	.435	.001**
Warm sweet drinks.	0	0.0	60	100.0	0	0.0	0	0.0	48	80.0	12	20.0	41	85	7	15	.841	.001**
Ensure dry.	0	0.0	60	100.0	0	0.0	0	0.0	60	100.0	0	0	57	95	3	5	.272	.001**
Cover- close wound.	0	0.0	60	100.0	0	0.0	0	0.0	60	100.0	0	0	51	85	9	15	2.655	.001**
Humidified gases and ventilation.	0	0.0	60	100.0	0	0.0	0	0.0	12	20.0	48	80.0	10	83	2	17	3.841	.001**
Radiant warmer.	0	0.0	60	100.0	0	0.0	0	0.0	60	100.0	0	0	53	88	7	12	.269	.001**
Achieve Movement	0	0.0	60	100.0	0	0.0	0	0.0	60	100.0	0	0	58	97	2	3	.985	.001**
Others types of rewarming	0	0.0	60	100.0	0	0.0	0	0.0	60	100.0	0	0	47	78	13	22	.657	.001**

Table (4) shows that 48.3% of the studied nurses used warming blankets pre-intervention, and 86.2% of these practices were effective. Post-intervention, 88.3% of nurses reported using warming blankets, with 94% of these practices being effective. For warming IV fluids and blood, 30.0% of nurses practiced this pre-intervention, with 61.1% being effective. Post-intervention, this increased significantly to 85.0% usage, with 90% effectiveness.

Also, regarding warming the environment and clothing, only 21.7% of nurses practiced this pre-intervention, with 46.2% being effective. Post-intervention, 80.0% reported using this method, with 90% effectiveness (t = .241, P = .021). In addition, warming diets, sweet drinks, ensuring dryness, and covering wounds all showed dramatic improvements, with nearly 100% of nurses adopting these practices post-intervention and their effectiveness reaching significant levels (P < .05).

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Table (5) Mean score distribution of hemodynamic monitoring among critically ill patients (n= 60)

Vital signs			Mean (SD)	Min	Max	f	P
BP	Day 1	S	95.61(3.29)	94.967	96.647	36.82	.000**
		D	61.82(8.57)	59.602	64.031		
	Day 3	S	89.12(2.37)	88.714	89.883		
		D	56.90(7.96)	54.843	58.957		
	Day 5	S	101.09(2.67)	100.380	101.796		
		D	66.03(15.39)	62.058	70.009		
	Day 7	S	120.24 (14.81)	110.432	125.410		
		D	80.67(13.61)	70.150	90.183		
HR	Day 1		92.87(4.45)	91.716	94.017	424.54	.000**
	Day 3		100.13(2.87)	99.393	100.874		
	Day 5		107.40(3.90)	106.393	108.407		
	Day 7		114.08(5.02)	112.787	115.380		
Temp	Day 1		34.70(2.69)	33.490	36.913	3478.42	.000**
	Day 3		35.23(2.63)	34.033	36.424		
	Day 5		36.08(2.74)	35.857	37.306		
	Day 7		37.35(.77)	36.114	37.580		
RR	Day 1		21.55(1.91)	21.057	22.043	17320.01	.000**
	Day 3		23.77(1.42)	23.400	24.133		
	Day 5		26.55(1.67)	26.118	26.982		
	Day 7		29.90(2.31)	29.303	30.497		
CVP	Day 1		11.35(2.26)	10.766	11.934	1918.89	.000**
	Day 3		9.48(1.71)	9.041	9.926		
	Day 5		8.03(1.37)	7.681	8.386		
	Day 7		6.92(1.18)	6.611	7.222		
Urine output	Day 1		200.67(50.08)	187.730	213.604	2034.248	.000**
	Day 3		395.50(76.81)	375.658	415.342		
	Day 5		567.83(98.50)	542.388	593.278		
	Day 7		747.33(126.34)	714.696	779.971		

f- f-test p p-value D Diastolic S Systolic **highly statistical significance

Table (5) Illustrates that Systolic blood pressure increased from 95.61 ± 3.29 mmHg on Day 1 to 120.24 ± 14.81 mmHg on Day 7, while diastolic BP rose from 61.82 ± 8.57 mmHg to 80.67 ± 13.61 mmHg ($p < 0.001$). Heart rate increased from 92.87 ± 4.45 bpm on Day 1 to 114.08 ± 5.02 bpm on Day 7 ($p < 0.001$). In addition, the temperature rose from 34.70 ± 2.69°C on Day 1 to 37.35 ± 0.77°C on Day 7 ($p < 0.001$), and the respiratory rate increased from 21.55 ± 1.91 breaths/min to 29.90 ± 2.31 breaths/min ($p < 0.001$). Central venous pressure declined from 11.35 ± 2.26 mmHg on Day 1 to 6.92 ± 1.18 mmHg by Day 7 ($p < 0.001$). As well as, the urine output improved from 200.67 ± 50.08 ml on Day 1 to 747.33 ± 126.34 ml on Day 7 ($p < 0.001$).

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Table (6) Mean score distribution Glasgow coma scale critically ill patients (n= 60)

Items	Sub-items	Glasgow Coma Scale								F	P
		1st day		3rd day		5th day		7th day			
		N	%	N	%	N	%	N	%		
Eye opening	Spontaneously	10	16.70	20	33.30	35	58.30	50	83.30	10.73	.001**
	Verbal command.	15	25.00	25	41.70	20	33.30	8	13.30		
	To pain	25	41.70	10	16.70	5	8.30	2	3.30		
	None	10	16.70	5	8.30	0	0.00	0	0.00		
Total	**Mean (SD)**	1.5 (0.7)		2.3 (0.8)		3.3 (0.7)		3.9 (0.3)			
Verbal	Oriented.	8	13.30	15	25.00	30	50.00	50	83.30	9.624	.001**
	Disoriented	20	33.30	25	41.70	20	33.30	8	13.30		
	Inappropriate answers	15	25.00	10	16.70	5	8.30	2	3.30		
	Incomprehensible	10	16.70	5	8.30	3	5.00	0	0.00		
	None	7	11.70	5	8.30	2	3.30	0	0.00		
Total	**Mean (SD)**	1.3 (0.8)		2.4 (0.7)		3.6 (0.6)		4.5 (0.5)			
Motor	Obeys commands.	5	8.30	15	25.00	30	50.00	45	75.00	4.257	.001**
	Purposeful movement.	10	16.70	25	41.70	20	33.30	10	16.70		
	Withdraws from pain	25	41.70	15	25.00	8	13.30	3	5.00		
	Abnormal flexion	10	16.70	3	5.00	2	3.30	2	3.30		
	Abnormal extension	5	8.30	2	3.30	0	0.00	0	0.00		
	None	5	8.30	0	0.00	0	0.00	0	0.00		
Total	**Mean (SD)**	2.0 (1.0)		3.5 (1.0)		4.8 (0.7)		5.7 (0.5			

Table (6) Illustrates that Systolic blood pressure increased from 95.61 ± 3.29 mmHg on Day 1 to 120.24 ± 14.81 mmHg on Day 7, while diastolic BP rose from 61.82 ± 8.57 mmHg to 80.67 ± 13.61 mmHg ($p < 0.001$). Heart rate increased from 92.87 ± 4.45 bpm on Day 1 to 114.08 ± 5.02 bpm on Day 7 ($p < 0.001$). In addition, the temperature rose from 34.70 ± 2.69°C on Day 1 to 37.35 ± 0.77°C on Day 7 ($p < 0.001$), and the respiratory rate increased from 21.55 ± 1.91 breaths/min to 29.90 ± 2.31 breaths/min ($p < 0.001$). Central venous pressure declined from 11.35 ± 2.26 mmHg on Day 1 to 6.92 ± 1.18 mmHg by Day 7 ($p < 0.001$). As well as, the urine output improved from 200.67 ± 50.08 ml on Day 1 to 747.33 ± 126.34 ml on Day 7 ($p < 0.001$).

Table (7) Mean score distribution of the Richmond agitation–sedation scale critically ill patients (n= 60)

The Richmond Agitation–Sedation Scale						
Items	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**f**	**P**
1st day	-5	-2	-3.50	1.097	199.437	.000**
3rd day	-4	-1	-2.50	1.097		
5th day	-3	0	-1.50	1.097		
7th day	-2	1	-.50	1.097		

Table (7) illustrates that the mean (SD) was -3.50±1.097for The Richmond Agitation–Sedation Scale in critically ill patients on 1st day and improved to a mean (SD) was -.50±1.097 on 7th day.

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Table (8) Mean score distribution of patients' laboratory investigations throughout pre-post intervention (n= 60).

Variable	Patient's laboratory investigations				f	P
	1st day	3rd day	5th day	7th day		
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)		
ABG						
PH	7.28±.02	7.33±.02	7.34±.01	7.36±.01	0.653	.000**
Paco2	.00±.00	.00±.00	38.5±2.9	39.50±2.9	7.465	.000**
Pao2	.00±.00	.00±.00	91±5.79	89±5.79	1.827	.000**
Hco3	.00±.00	.00±.00	25±1.43	24±1.43	7.384	.000**
BE	-.63±.71	-1.47±.89	.00±.71	-1.00±.71	1.637	.000**
SAO2	.96±.02	.94±.02	98±1.43	97±1.43	3.352	.000**
PH	7.28±.02	7.33±.02	7.34±.01	7.36±.01	0.657	.000**
Paco2	.00±.00	.00±.00	38.5±2.9	39.50±2.9	7.468	.000**
CBC						
HB	12.84±.48	12.96±.45	13.75±.55	13.75±.55	0.655	.000**
WBC	9880.00±588.82	10140.00±624.69	11.00±1.43	10.00±1.43	16.768	.000**
Plat	167233.33±10931.7	171500.00±11871.4	255.00±28.97	245.00±28.97	156.475	.000**
Coagulation Profile						
PT	11.97±.76	12.03±.76	14.50±1.10	13.50±1.10	0.35	.000**
PTT	23.93±.95	24.93±1.95	30.00±2.85	29.00±2.85	0.333	.000**
INR	1.02±.04	1.03±.05	1.20±.08	1.10±.08	0.406	.000**
Electrolytes						
Na	136.00±.82	137.00±.82	136.50±1.07	137.43±1.03	0.351	.000**
Mg	1.95±.11	2.05±.11	1.70±.11	1.64±.10	0.402	.000**
K	4.20±.16	4.30±.16	4.12±.13	4.20±.12	0.362	.000**
Renal Function						
Urea	44.93±2.65	47.00±2.86	33.50±8.61	32.50±8.61	8.691	.000**
Creat	1.00±.22	1.10±.22	.95±.10	.86±.11	6.706	.000**
Liver Function						
AST	30.00±7.13	31.00±7.13	30.40±2.06	29.03±1.68	0.009	.000**
ALT	28.50±5.48	27.50±5.48	35.70±2.07	34.70±2.07	0.443	.000**
f- f-test p p-value **highly statistical significance						

Table (8) presents that regarding ABG, there is an increase in SAO2 from 96% on day 1 to 97±1.43 on day 7. In CBC, platelet counts significantly increased from 167,233±10,931 on day 1 to 245,000±28.97 on day 7. For coagulation, PT rose from 11.97±0.76 on day 1 to 13.50±1.10 on day 7. Regarding electrolytes, magnesium decreased from 1.95±0.11 on day 1 to 1.64±0.10 on day 7. In renal function, UREA dropped from 44.93±2.65 on day 1 to 32.50±8.61 on day 7, and creatinine decreased from 1.00±0.22 on day 1 to 0.86±0.11 on day 7. Finally, liver function showed an increase in ALT from 28.50±5.48 on day 1 to 34.70±2.07 on day 7. All changes were statistically significant between all four days.

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Table (9): Effect size and η2 of rewarming manoeuvers intervention on critically ill patients general assessment (n = 60)

Variables	Mean	SD	F	P	η^2	Effect size
Pre-intervention	3.68	1.03	2668.55	0.001**	0.978	Large effect
Post-intervention	23.00	2.79				

*Significant p ≤ 0.05 **Highly significant p ≤ 0.01 F: ANOVA Test

* Small effect size = 0.01 to < 0.06 **Medium effect size =0.06 to < 0.14 ***Large effect size ≥ 0.14

Table (9) shows that there is highly statistically significance correlation between rewarming device and critically ill patients general assessment with a large effect size (η^2 = 0.978) at p value 0.001** in pre and post intervention.

Discussion

Since hypothermia in severely ill patients can be effectively treated with rewarming techniques, which help bring the body temperature back to normal and avoid negative consequences, they are crucial. The selection and efficacy of these methods are greatly influenced by the degree of hypothermia. Mild hypothermia (core temperature between 32°C and 35°C) is often treated using passive external rewarming techniques such as blankets and warm environments, which rely on the patient's heat to slowly elevate their body temperature (***Smith et al., 2020).***

The current study aimed to identify the effect of rewarming manoeuvers on the severity of hypothermia among critically ill patients. Also, the research hypothesis of this study was formulated as the implementation of rewarming manoeuvers would positively affect the severity of hypothermia among critically ill patients. In addition, the present study included a convenient sample of all available adult patients (60) diagnosed with hypothermia, who are admitted to the intensive care units for six months.

In relation to studied patient personal data; the results revealed that most of the studied patients were aged ≥ 50 years old with a mean (SD) of 60.84 ± 8.72 and more than half of them were males. Regarding marital status, more than two-fifths of them were married. In addition, more than one-third of them had basic education. Also, nearly three-fifths were housewives, and three-fifths lived in urban areas. In addition to less than a third of critically ill patients were classified as overweight regarding nutritional status, with a mean of BMI 28.77 ± 3.66. The mean weight was 80.00 ± 15.41 kg, and the mean height was 166.03 ± 6.77 cm.

This matched with ***Chung et al. (2023),*** who studied "Impact of Active Rewarming on Outcomes in ICU Patients with Hypothermia." in South Korea, and stated that about one-third of their studied participants, were aged 18-40, one-half of them aged 41-60, and a fifth of them were over 60 years. In addition, more than half of their studied participants were males and less than half were females.

In addition, this result was in agreement with those of ***Sari et al. (2021),*** who studied "The incidence of inadvertent perioperative hypothermia in patients" and found a higher incidence of hypothermia among overweight patients (BMI ≥ 25 kg/m²) and those with comorbidities.

Regarding the studied patients' current diagnosis and comorbidities; the results showed that half of patients have an infection, allergy, and sepsis. Also, less than half of patients had diabetes and more than a third had hypertension. From researchers' point of views overweight and obesity are associated with a higher incidence of chronic conditions like type 2 diabetes, hypertension, cardiovascular disease, and sleep apnea. Patients with these pre-existing conditions are often at higher risk of developing critical illnesses that necessitate ICU admission and induced impaired thermoregulation.

The present study findings were in accordance with **Ahmed et al., (2024)** reported that less than one-quarter of the studied patients were hypertensive, and less than a fifth had no chronic diseases. While, these findings disagreed with **Chung et al., (2023),** who mentioned that comorbidity: two-fifths of the studied had cardiovascular diseases, and about one-third of them had diabetes. While a minority of the studied patients documented an allergy.

In relation to connected devices induced hypothermia the result illustrated that less than half of patients had nasogastric tubes for feeding, while about a third used nasal cannulas as artificial airways. Chest tubes and urinary catheters were used in half and majority of patients, respectively. Mechanical ventilators were

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connected to more than two-thirds of patients, and three-fifth had cannulas for vascular access. This result supported by **Al-Badawi et al. (2021),** highlighted that four-fifths of the sample were using mechanical ventilators, and two-thirds had vascular cannulas.

Regarding nurses' practices regarding rewarming manoeuvers of hypothermic patients among critically ill patients' pre – and post-intervention, the current study revealed that about half of the studied nurses used warming blankets pre-intervention, and the majority of these practices were effective. Post-intervention, the majority of the studied nurses reported using warming blankets, and most of these practices were effective. For warming IV fluids and blood, less than one-third of the studied nurses practiced this pre-intervention, with about two-thirds of them being effective.

As well, post-intervention, this increased significantly to the majority usage, with most of these being effectiveness. Regarding warming the environment and clothing, about one-quarter of the studied nurses practiced this pre-intervention, with about half of these being effective. Post-intervention, the majority of them reported using this method, with most being effectiveness. In addition, warming diets, sweet drinks, ensuring dryness, and covering wounds all showed dramatic improvements, with nearly all of them adopting these practices post-intervention and their effectiveness reaching significant levels. These might be due to warming blankets being easy to use and widely available in ICU settings. Similarly, providing warm sweet drinks and a warm diet are simple yet effective measures that can be easily integrated into patient care routines. Also, there might have been strong institutional support at Cairo Hospitals for these specific methods, including the availability of resources and encouragement from healthcare leaders to adopt these practices.

This discrepancy might be attributed to insufficient warming materials, measurement materials, guidelines or protocols, and nurse training opportunities. These results were in accordance with ***Park et al. (2021),*** who studied the "Effect of active rewarming on outcomes of hypothermic patients in critical care units." in South Korea, (n=80) reported that warming blankets were the most effective, with 70% of patients achieving normothermia within 4 hours post-intervention. Significant improvement in patient outcomes with systematic training of nurses.

In relation to the studied patients' clinical outcome assessment; the result illustrates in concern vital signs that systolic blood pressure increased from 95.61 ± 3.29 mmHg on Day 1 to 120.24 ± 14.81 mmHg on Day 7, while diastolic BP rose from 61.82 ± 8.57 mmHg to 80.67 ± 13.61 mmHg ($p < 0.001$). Heart rate increased from 92.87 ± 4.45 bpm on Day 1 to 114.08 ± 5.02 bpm on Day 7 ($p < 0.001$). In addition, the temperature rose from 34.70 ± 2.69°C on Day 1 to 37.35 ± 0.77°C on Day 7 ($p < 0.001$), and the respiratory rate increased from 21.55 ± 1.91 breaths/min to 29.90 ± 2.31 breaths/min ($p < 0.001$). Central venous pressure declined from 11.35 ± 2.26 mmHg on Day 1 to 6.92 ± 1.18 mmHg by Day 7 ($p < 0.001$). As well as, the urine output improved from 200.67 ± 50.08 ml on Day 1 to 747.33 ± 126.34 ml on Day 7 ($p < 0.001$). From researchers' point of views, these parameters serve as critical indicators of a patient's hemodynamic stability and overall prognosis during treatment.

These results matched with a cohort of 3951 ICU admissions by **White et al., (2024)** whose studied "Hypothermia and influence of rewarming rates on survival among patients admitted to intensive care with bloodstream infection" and found that the lowest temperature measured within the first 24 hours of admission was identified, and among those who were hypothermic (<36°C), the rewarming rate [(time difference between lowest and subsequent first temperature ≥36°C) divided by hypothermia severity (difference between lowest measured and 36°C)] was determined. Within the first 24 hours of admission to the ICU, a minority and about one-quarter of subjects had the lowest temperature measurements ranging <34.9°C and 35–35.9°C, respectively.

In relation to Glasgow Coma Scale; the result of the study shows that tenth of the studied patients responded spontaneously for eye opening on the 1st day, which improved significantly to majority by the 7th day. Similarly, minority obeyed commands for motor response on the 1st day, increasing sharply to three-quarters on the 7th day. Additionally, minority were oriented in verbal response on the 1st day, improving markedly to majority by the 7th day.

A study done by **Polderman (2024),** whose study titled "Hypothermia and Influence of Rewarming Rates on Survival among Critically Ill Patients" conducted in the Netherlands with 100 hypothermic ICU patients, found that active rewarming led to significant improvements in neurological outcomes, with GCS

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scores increasing from an average of 6 on day 1 to 12 on day 7. Electrolyte imbalances were corrected more rapidly in the active rewarming group compared to passive rewarming.

In relation to the Richmond Agitation–Sedation Scale; the result of the study illustrates that the mean (SD) was lower mean score for the Richmond Agitation–Sedation Scale in critically ill patients on 1st day and improved to a mean (SD) was higher mean score on 7th day. This finding was consistent with **Chung et al., (2023),** who found that active rewarming improved sedation levels (RASS scores) with a statistically significant decrease in agitation levels over five days. In addition, **Brown et al. (2022)**, who study "Therapeutic rewarming in post-operative ICU patients" and agreed with a reduction in agitation measured by RASS with a mean score of -2.5 ± 0.9 by day 5).

In relation to laboratory investigation; the results of the study presents that regarding ABG, there is an increase in SAO2 from on day 1 to (97±1.43) on day 7. In CBC, platelet counts significantly increased from (167,233±10,931) on day 1 to (245,000±28.97) on day 7. For coagulation, PT rose from (11.97±0.76) on day 1 to (13.50±1.10) on day 7. Regarding electrolytes, magnesium decreased from (1.95±0.11) on day 1 to (1.64±0.10) on day 7. In renal function, UREA dropped from (44.93±2.65) on day 1 to (32.50±8.61) on day 7, and creatinine decreased from (1.00±0.22) on day 1 to (0.86±0.11) on day 7. Finally, liver function showed an increase in ALT from (28.50±5.48) on day 1 to (34.70±2.07) on day 7. All changes were statistically significant between all four days.

This result was supported by **Chung et al., (2023),** who stated that arterial blood gas (ABG) levels showed significant improvement in pH (7.29 ± 0.03 to 7.36 ± 0.02) and SaO2 (96% ± 2.5 to 98% ± 1.5) by the seventh day. Consistent improvements were noted in hemodynamic and coagulation profiles. In addition, **Brown et al. (2022)**, mentioned that there was improvement in core temperature led to better ABG parameters, particularly pH (7.28 ± 0.02 to 7.37 ± 0.01).

This might be attributed to **De Garibay et al. (2022)** whose study entitled "Critical care hepatology: definitions, incidence, prognosis and role of liver failure in critically ill patients" and suggesting that liver dysfunction in critically ill patients can indeed be associated with various factors like dysregulation of the inflammatory response, persistent microcirculatory impairment, and drug-induced liver injury. These factors might contribute to the observed significant changes in renal and liver function over seven days in critically ill patients, highlighting the critical need for continuous monitoring and adjustment of treatment strategies. The current study referred to with specific p-values for urea, creatinine, AST, and ALT aligned with this understanding, emphasizing the importance of managing and monitoring liver and renal function in the ICU.

This finding was supported by **Yang (2020)** who study entitled "Hepatic dysfunction in critically ill patients" in South Korea. This study explored the prevalence and progression of hepatic dysfunction in critically ill patients, focusing on liver function parameters such as AST (aspartate aminotransferase) and ALT (alanine aminotransferase). Findings showed statistically significant elevations in AST and ALT levels in critically ill patients, indicating hepatic stress, with correlations to disease severity and hypothermia-induced stress.

Concerning the correlation between the severities of hypothermia severity and rewarming device efficiency in critically ill patients, the current study found that there was a highly statistically significant correlation between the severity of hypothermia and rewarming devices in pre and post-intervention. This positive correlation might be due to as the efficiency of the rewarming devices improves, the severity of hypothermia decreases more effectively. In other words, more efficient rewarming devices have a greater impact on reducing the severity of hypothermia in critically ill patients.

This finding was supported by **Sugiyama et al., (2024)**, who studied "Effects of rewarming therapies on outcomes in accidental hypothermia" in Japan, supported these findings and reported that implementing rewarming maneuvers significantly impacted the severity of hypothermia in ICU patients. Their study found that active rewarming techniques, and conventional therapies, were associated with improved outcomes in patients with hypothermia. Specifically, they observed that faster rewarming rates were linked to better survival rates and reduced severity of hypothermia.

Conclusion

On the light of the current study finding; this study concluded that less than one-fifth of nurses had competent practice regarding rewarming manoeuvers pre-intervention, which improved to two-thirds at post-intervention. In addition, about one-third of standard nurses had efficient use of rewarming manoeuvers at pre-

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intervention, which improved to about two-thirds at post-intervention. As hypotheses, there was a highly statistically significant negative correlation between total practices and patient general assessment with a large effect size of rewarming manoeuvers at post-intervention.

Recommendation

On the light of the findings of the current study recommended the following:

- Create and distribute unambiguous standard operating procedures (SOPs) for rewarming patients who are hypothermic.
- Regularly run simulation exercises to make that ICU personnel are equipped to manage hypothermia situations.

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