Effect of a Training Program on Nurses' Performance Regarding Care of Infants with Chest Tube and Clinical Outcomes

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Abstract

Background: Chest tube drainage is a critical intervention for infants with pleural air or fluid accumulation. Safe nursing care depends on sound knowledge and consistent bedside practice. **Aim:** To evaluate the effectiveness of a training program on nurses' performance regarding care of infants with chest tube and clinical outcome. **Design:** A quasi-experimental design. **Setting:** Neonatal and pediatric intensive care units at Minya Al Qamh Central Hospital, Sharqia governorate. Egypt. **Sample:** 40 nurses, who, provide nursing care of infants with chest tube and agreed to participate in this study and 60 infants (30 infants as a control and 30 infants as an intervention or case group) were recruited from the previously mentioned hospital. **Tools: Tool (I)** A Structured interview Questionnaire, it consisted of two parts; Part 1: Personal data of the Studied Nurses and Part 2: Nurses' knowledge regarding chest tube in infants, **Tool (II)** Observational Checklist and **Tool (III)** composed of two parts Assessment of studied infants Part (1): Characteristics of studied infants and Part (2): Chest tube associated complications assessment sheet. **Results:** Good total knowledge increased from 17.5% to 82.5% (reported P<0.001), and satisfactory total practice from 75.0% to 95.0% (P=0.012) after training. Knowledge and practice were positively correlated both before (P=0.008) and after (P<0.001) training. At least one complication occurred in 7/30 infants (23.3%) in the study group and 13/30 (43.3%) in the control group (P=0.170). **Conclusion:** The training program was associated with improvements in nurses' knowledge and practices; evidence of a statistically significant reduction in overall infant complications was not established. **Recommendations:** Implement periodic competency-based training and structured chest-drain safety monitoring

Keywords: Chest tube; Infants; Nursing knowledge; Nursing practice; Training program; Clinical outcomes.

Introduction

Chronic kidney disease (CKD) is frequently described through loss of filtration capacity, yet its systemic Chest tube drainage is an invasive but frequently necessary measure for removing air or fluid from the pleural cavity and promoting re-expansion of the lung. Closed underwater-seal drainage systems permit evacuation while limiting the backflow of air into the chest. In neonatal and pediatric intensive care, the effectiveness of a chest drain depends not only on successful insertion but also on correct system assembly, appropriate positioning, continuous observation, and early escalation of abnormal findings. Because deterioration can be rapid in an infant with limited respiratory reserve, safe chest-drain management is a fundamental part of critical nursing care (Royal Children's Hospital Melbourne, 2022).

Pneumothorax is an important indication for chest drainage in the newborn period and may develop in association with respiratory distress, respiratory support, or an underlying lung disorder. Its presentation ranges from mild respiratory compromise to severe cardiovascular instability. Clinical assessment and imaging, including chest radiography and, when available, lung ultrasonography, help establish the diagnosis. Treatment is guided by the infant's condition and may involve observation, needle aspiration, or chest tube insertion when ongoing pleural drainage is needed. The choice of intervention therefore requires prompt clinical judgment and careful monitoring (Jhaveri et al., 2024).

Chest drainage is also considered for pleural fluid collections that interfere with respiration, including parapneumonic effusion and empyema. Drain size and technique are selected in relation to patient age, the clinical indication, and the characteristics of the collection. A 2024 pediatric guideline suggests small-bore rather than large-bore drains for children from three months to 18 years with parapneumonic effusion requiring drainage, although the underlying evidence was judged to be of very low certainty. This age restriction should be recognized when applying pediatric evidence to younger neonates (Sorino et al., 2024).

Insertion and management of neonatal chest drains demand an organized clinical approach because a vulnerable infant may require urgent intervention while receiving intensive respiratory support. Neonatal guidance emphasizes the need for appropriate assessment before the procedure when clinically feasible, confirmation of tube placement after insertion, clear procedural documentation, and competent post-insertion observation. Nurses contribute to readiness by preparing sterile equipment, supporting physiological monitoring, checking that the drainage unit is functional, and communicating changes promptly. These processes create a consistent framework for safe chest-drain care in neonatal units (Zolfaghari & Lee, 2024).

A chest tube may be associated with mechanical, procedural, and infectious complications. Injury to thoracic structures, bleeding, obstruction, malposition, disconnection, and accidental dislodgement can impair drainage or worsen respiratory compromise. Safe insertion technique and ongoing surveillance are particularly important in neonates because of their small anatomical dimensions and the possibility of rapid clinical deterioration. Neonatal clinical guidance stresses sterile technique, attention to vascular and organ injury, and urgent senior review whenever serious injury or malfunction is suspected. Nursing vigilance is therefore essential throughout the period of drainage (Sorino et al., 2024).

Nurses have responsibility for assessing the infant and the drainage system, monitoring respiratory status and drainage characteristics, preventing kinking and disconnection, maintaining insertion-site care, and documenting findings. Nevertheless, these skills may not be consistently achieved without focused education and supervised practice. In a quasi-experimental Egyptian study involving 50 nurses caring for infants with chest tubes, Arafa and colleagues found improvement in nurses' knowledge and observed practice following an educational program. Their findings support continuous, procedure-specific professional development for nurses undertaking this high-risk care (Arafa et al., 2022).

Structured educational interventions are increasingly used to improve the translation of critical-care knowledge into bedside performance. An Egyptian study of pediatric intensive-care nurses reported marked improvements in knowledge and observed practices after an educational program on the pediatric liberation bundle. Although this intervention did not focus specifically on chest tubes, it

supports the wider value of targeted teaching and assessment in pediatric critical-care nursing. Accordingly, the present study examined whether a focused training program could improve nurses' knowledge and practices in infant chest-tube care and explored related infant clinical outcomes (Baraka et al., 2024).

Significance of the Study

Chest-tube care in infancy warrants particular attention because the clinical conditions requiring drainage can threaten respiratory stability, while preventable problems with tubing, water-seal systems, positioning, or surveillance can add to the infant's risk. A Malaysian multicenter neonatal registry analysis reported 3,265 pneumothoraces, of which 62.5% occurred during respiratory support, illustrating the importance of this problem in critical neonatal care. The present investigation was therefore undertaken to identify nurses' training needs, evaluate changes in their knowledge and bedside practices after a structured program, and compare recorded chest tube-associated complications between infant groups. Its findings may inform unit-based competency training and quality-improvement activities; however, between-group complication outcomes must be interpreted according to their observed statistical significance (Boo et al., 2023).

Aim of the Study

To evaluate the effectiveness of a training program on nurses' performance regarding care of infants with chest tube and clinical outcome.

Research Hypotheses

H1: Nurses' knowledge regarding infant chest-tube care improves after implementation of the training program.

H2: Nurses' observed practices regarding infant chest-tube care improve after implementation of the training program.

H3: The training program is associated with improved clinical outcomes, as assessed by chest tube-associated complications among infants

Subjects and Method

Study Design:

A quasi-experimental design which distributed as, one group of nurses pre & post-test and two groups of infants (case and control) were utilized to conduct this study.

Study Setting:

The current study was conducted at Minya Al Qamh Central Hospital at Minya Al Qamh city of Sharqia governorate in neonatal intensive care units (NICUs) and pediatric intensive care units (PICU) **.**

Study Subjects

Group (I): The participants of this study were 40 nurses, who, provide nursing care of infants with chest tube and agreed to participate in this study.

Group (II): 60 infants (30 infants as a control and 30 infants as an intervention or case group) were recruited from the previously mentioned hospital after fulfilled the following criteria.

Inclusion criteria:

1. Infants' age from birth to one year of age.
2. Infants connected with chest tube regardless the medical indication for chest tube.**Tools of Data Collection**

Tool I - A Structured interview Questionnaire;

It was developed by the researcher after reviewing of literature to collect data. It was developed in Arabic language and it consisted of two parts: Part 1: Personal data of the Studied Nurses

Part 2: Nurses' knowledge regarding chest tube in infants

:Tool II—Observational checklist: Assessed nurses' performance in pre-insertion assessment, infant preparation, procedural assistance, drainage-system patency, insertion-site dressing care, removal-related assessment, documentation, and safety management.

Tool III— Assessment of studied infants: composed of two parts: Part (1): Characteristics of studied infants and Part (2): Chest tube associated complications assessment sheet

Training Program and Study Procedure

The study protocol described seven training sessions covering initial assessment; infant respiratory anatomy and physiology; chest-tube concepts, indications and equipment; insertion-related preparation; routine care, drainage-system surveillance and complication detection; removal-related care; and final evaluation. Sessions were scheduled in groups of approximately 9–10 nurses, lasting about 30–45 minutes each, using lectures, discussion, video, demonstrations and re-demonstrations. Nurses' knowledge and observed practice were assessed before and after the program, and infant complications were compared across the reported study and control groups.

Validity of study tools:

For validity assurance purposes, tools were developed after a thorough review of the related literature and then submitted to a panel of three experts in the field of pediatric nursing, faculty of nursing, Zagazig university to determine the extent to which the items related to each other, clarity, relevance, comprehensiveness, simplicity and applicability. The necessary modifications were done accordingly reliability performed to confirm validity of the study tools.

Pilot Study:

It was carried out on (10%) of sample size (4) nurses caring for (6) infants connected with chest tube at the previously mentioned setting to test applicability, feasibility, and practicability of the tool. All in the pilot study were included in the total sample, as where no modifications were carried out in the study tools as revealed from the pilot study.

Ethical Considerations

Ethical approval for conducting the current study was obtained from the scientific research ethics committee at the Faculty of Nursing, Zagazig University. Consent was obtained from the infants' guardians and nurses before data collection with ensuring complete privacy and confidentiality after a full explanation of the aim and process of the study. The researcher assured the participants the data which will be used for research purposes only. Also, right to withdraw from the study at any phase was assured.

Field work:

1. Before data collection, the researcher met infants' guardians and the consent was obtained.
2. The consent was obtained from each nurse and informed them about the title, aim, tools, the study technique and the outcomes of the study to obtain their approval and cooperation which is needed for conducting this study.
3. The following phases were followed the aim of the current study; assessment, planning, implementation and evaluation phases. These phases covering period of 8 months (from the beginning of July 2023 to the end of February 2024). Data were collected 3 days/week (Sunday, Tuesday and Thursday) from 9 a.m to 2 p.m in previous mentioned setting.

1- Assessment phase:-

• Assessment control group of infants (30) before starting any steps of educational program by using chest tube associated complications assessment sheet.

• The Program was constructed based on the educational needs of the studied nurses that were derived from the results of the assessment phase (pre-test questionnaire). This assessment phase shed light and gave more insight into deficits in care of infants with chest tube knowledge, practices and clinical outcomes and helped in identifying their educational needs before implementation of the program.

2- Planning phase:-

Based on the results obtained from the pretest during assessment phase and pilot study as well as reviewing the related literature, the program was developed by the researcher. Detected needs, requirements and deficiencies were translated into the aim and objectives of the program. The content of educational programs was selected based on identified needs. A booklet was prepared, and specific committee validated the content of booklet to be distributed to the studied nurses as a guide for learning.

3- Implementation phase:-

The educational program of this study was implemented through seven sessions in which the studied

nurses were interviewed in (4-5) groups which each group consist of (9-10) nurses according to their availability. The length of each session differed According to the content of the session and nurses' responses. Each session started by the objectives and involved theoretical and practical parts and lasted for (45-60min).

The Educational Program

General Objectives of the Program: The study was conducted to evaluate the effectiveness of a training program on nurses' performance regarding care of infants with chest tube and clinical outcome.

Specific Objectives of the Program:

- Improve the nurses' knowledge regarding care of infants with chest tube.
- Improve the nurses' practice regarding care of infants with chest tube.
- Enhance clinical outcome.

Program time and sessions content:-

The total time used in a training program is 7 hours (3 hours theoretical & 4hours practical) conducted as;

- Time for each session was 45 to 60 minutes.
- 7 sessions (theoretical & practical).
- 1st session included (aim of the training program, introduction, pretest and divide the group of nurses), 2nd session involved (anatomy and physiology of the respiratory system), 3rd session contained (definition, size, material and indications for chest tube), 4th session included installation of chest tube (prepare equipment, position of the infant during the insertion of the chest tube, drainage system and insertion site of chest tube), 5th session included routine daily care of chest tube (changing bottle of chest tube, role of the nurse during the transportation of the infant with chest tube to another place, care of the insertion site, time of chest tube removal and monitor for complications), 6th session include Chest Tube removal such as, (causes of removal, clamping chest tube before removal and maneuver during chest tube removal) and 7th session the last session which contained (conclusion of the main points of the training program, posttest and acknowledgment to nurses)

Methods of teaching:-

- Discussion.
- PowerPoint presentation.
- Demonstration and re-demonstration.

Media used:-

- Illustrated booklet.
- Brochure.
- Colored posters.

4- Evaluation phase (post-test)

In this phase, knowledge of all the studied nurses was reassessed immediately after implementation of the educational program by using tool (I) part 2, while practices of studied nurses was assessed by using tool (II) and infants' outcome reassessed by using tool (III) part 2.

Statistical Analysis

Descriptive data are presented as numbers, percentages, means and standard deviations. Correlation coefficients and P-values for changes in nursing knowledge and practice were transcribed from the source Results file; the type of correlation statistic and paired individual-level data were not available for independent validation. For the selected binary infant complications, two-sided Fisher's exact P-values were recalculated from the reported 2×2 group counts because of small cell frequencies; these explicitly replace the source table's uncorrected chi-square P-values. $P<0.05$ was used as the nominal significance threshold, without adjustment for multiple comparisons.

Results:

Table (1) figures the demographic and professional characteristics of the studied nurses. It was found that more than half of the studied nurses (55.0%) were aged 20–<30 years, with a mean age of 29.7 ± 7.1 years. The majority of the studied nurses were females (80.0%). Regarding job title, most of the participants (85.0%) were nursing technicians. Concerning work location, the majority of the studied nurses (85.0%) worked in the Neonatal Intensive Care Unit (NICU), while 15.0% worked

in the Pediatric Intensive Care Unit (PICU).

Regarding years of experience in the aforementioned units, 35.0% of the studied nurses had 1–<3 years of experience, followed by 30.0% who had 3–<6 years, with a mean experience of 5.3 ± 3.7 years. Concerning training in chest tube care, the majority of the studied nurses (70.0%) had not attended any training courses related to chest tube care, whereas 30.0% had attended such courses.

Table (2) shows a statistically significant improvement in nurses' knowledge regarding chest tubes after implementation of the training program. The percentage of nurses who provided correct answers increased across all knowledge items after the training program (P<0.001).

Table (3) demonstrates a significant improvement in participants' overall knowledge following the training program. Before training, 42.5% to 57.5% of participants had poor knowledge, while only 15.0%–22.5% had good knowledge. Following the training, the proportion with good knowledge increased markedly to 77.5%–85.0%, whereas poor knowledge decreased to only 2.5%–5.0%. The most pronounced improvement was observed in knowledge after chest tube insertion, where good knowledge increased from 22.5% to 85.0%. Statistically significant differences were found for all knowledge areas (P < 0.001), indicating a significant improvement in participants' overall knowledge following the training program.

Figure (1) illustrates highly statistically significant improvement in total knowledge score about chest tube. Prior to the implementation of the educational program, a substantial knowledge gap was evident, with 50.0% of the participants exhibiting a poor total knowledge level, 32.5% demonstrating an average knowledge level and only 17.5% possessing a good baseline knowledge level. Following the execution of the educational intervention, a profound upward shift in knowledge was observed, as the proportion of nurses achieving a good total knowledge level expanded dramatically to 82.5%, whereas those with average knowledge fell to 15.0% and the percentage of nurses with poor knowledge dropped sharply to 2.5%.

The table (4) indicates a statistically significant improvement in nurses' practices related to the care of infants with chest tubes following the implementation of the training program. Before the program, the proportion of nurses achieving satisfactory practice varied across the different practice domains, ranging from 62.5% for practices related to the chest tube procedure to 82.5% for safety management. Following the training, satisfactory practice increased markedly in all domains, reaching 90.0%–97.5%, while the proportion of unsatisfactory practice decreased considerably to only 2.5%–10.0%.

Figure (2) illustrates the total practice levels of the studied nurses regarding the care of infants with chest tubes across the pre- and post-intervention phases (n = 40). Prior to the implementation of the educational program, (75.0%) of studied nurses exhibited a satisfactory total practice level, while (25.0%) of them demonstrated an unsatisfactory practice performance. Following the execution of the educational program, a statistically significant enhancement in nursing practice performance was achieved (p = 0.012). The proportion of nurses demonstrating satisfactory clinical practice rose substantially to 95.0%, whereas those categorized with unsatisfactory practice dropped markedly to only 5.0%.

Regarding the baseline personal characteristics of the studied infants at **table (5),** the findings revealed a generally comparable distribution between the case and control groups. In terms of age, infants in both groups were distributed across the different age categories, with the highest proportion in the case group being aged from birth to ≤28 days (40.0%), while the corresponding highest proportion in the control group was aged >28 days to ≤3 months (36.7%). The mean age was almost identical between the two groups, measuring 2.63±2.65 months in the case group and 2.64±2.46 months in the control group.

With respect to gender, males represented slightly more than half of the infants in both groups, accounting for 53.3% of the case group and 56.7% of the control group, while females constituted 46.7% and 43.3%, respectively. Similarly, the mean body weight was comparable between the case and control groups (5.95±0.91 kg and 5.83±1.04 kg, respectively).

The medical history of the studied infants with chest tubes is presented in **Table (6).** Regarding medical diagnosis, the highest percentages of infants in both groups were diagnosed with pneumonia, accounting for 36.7% in the case group and 33.3% in the control group. Pneumothorax was identified as the primary indication for chest tube insertion, representing 60.0% of the case group and 53.3% of the control group.

In terms of the length of hospital stay, the majority of participants in both groups stayed between 7 and 14 days, with equal proportions of 40.0% in both the case and control groups. Overall, the vast majority of the studied infants (86.7%) were connected to a single chest tube, and the right lung was the most common insertion site, accounting for half of the total sample (50.0%).

Regarding the duration of chest tube insertion, nearly three-quarters of the case group (73.3%) had the tube inserted for less than 5 days, compared to (46.7%) in the control group. Conversely, insertion durations exceeding 5 days were more prevalent in the control group (53.3%) than in the case group (26.7%).

Figure (3) illustrates the percentage distribution of the studied infants regarding chest tube-associated complications between the study group and the control group. A statistically significant difference in complication rates was revealed between both groups (P = 0.038). Within the study group, whose care was guided by the implemented nursing intervention, the vast majority of infants (93.3%) experienced no complications, while only a small minority (6.7%) presented with chest tube-associated complications. In contrast, the control group exhibited a notably higher complication rate, where 26.7% of the infants developed complications, compared to 73.3% who remained complication-free.

Table (7) demonstrates the relationship between nurses' knowledge level and the occurrence of chest tube-related complications in the study and control groups.

Among nurses with a good knowledge level, the study group showed a higher proportion of infants without complications

(73.3%) compared with those with complications (10.0%). In contrast, in the control group, 50.0% were without complications and 30.0% experienced complications. This difference was statistically significant (p=0.009).

Table (8) demonstrates that: Pre-training There was a weak positive correlation between knowledge and practice. Post-training a very strong positive correlation emerged between knowledge and practice, meaning that nurses with higher knowledge scores also demonstrated better practice. Most importantly: Strong negative correlations were found between post-training knowledge and post complications, and between post-training practice and complications. This means that as nurses' knowledge and practice improved, chest tube-associated complications significantly decreased.

Table (1): Personal data of the studied nurses (n=40)

Personal data	No.	%
Gender		
Male	8	20.0
Female	32	80.0
Age/years		
18 -	2	5.0
20 -	22	55.0
30 -	12	30.0
40 - ≥	4	10.0
Mean±SD		29.7±7.1
Job title		
Nursing technician	34	85.0
Shift supervisor	4	10.0
Unit supervisor	2	5.0
Work location		
Neonatal intensive care unit	34	85.0
Pediatric intensive care unit	6	15.0
Years of experience working in the aforementioned units		
1 -	14	35.0
3 -	12	30.0
6 -	8	20.0
10 - ≥	6	15.0
Mean±SD		5.3± 3.7
Have you attended any training courses on chest tube care?		
Yes	12	30.0
No	28	70.0
"If yes, what training courses have you attended? (n=12)(more than one aswer)		
Thoracic drainage management workshop	9	75.0
Advanced pediatric critical care procedures	6	50.0
NICU Emergency Skill	5	41.7

Table (2): The Effect of the training program on knowledge of the studied nurses about chest tube (n=40)

Knowledge about chest tubes	Pre-training program		Post-training program		X^2	P-value
	Correct answer		Correct answer			
	No.	%	No.	%		
Definition of a chest tube	20	50.0	39	97.5	42.57	0.000**
Terms of a chest tube	18	45.0	39	97.5	32.15	0.000**
Material used to manufacture a chest tube	10	25.0	37	92.5	45.89	0.000**
Components of a chest tube	10	25.0	38	95	50.22	0.000**
Purpose of chest tube insertion	28	70.0	40	100	36.80	0.000**
Indications for chest tube insertion	18	45.0	39	97.5	41.03	0.000**
Contraindications for chest tube insertion	10	25.0	39	97.5	31.74	0.000**
Classifications of chest tubes according to function	6	15.0	38	95	38.96	0.000**
Types of chest drainage systems	20	50.0	40	100	47.11	0.000**
Complications of chest tube insertion	25	62.5	40	100	44.65	0.000**

Table (3): The Effect of the training program on Total scores of chest tube knowledge and its domains as reported by the studied nurses (n=40).

Subtotal items of knowledge	Pre-training program						Post-training program						X^2	P-value
	Good		Average		Poor		Good		Average		Poor			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%		
Knowledge about chest tubes	6	15.0	11	27.5	23	57.5	31	77.5	8	20.0	1	2.5	58.33	0.000**
Knowledge during chest tube insertion	7	17.5	12	30.0	21	52.5	33	82.5	5	12.5	2	5.0	52.18	0.000**
Knowledge after chest tube insertion	9	22.5	14	35.0	17	42.5	34	85.0	5	12.5	1	2.5	66.42	0.000**
Knowledge about removing a chest tube	7	17.5	13	32.5	20	50.0	33	82.5	6	15.0	1	2.5	62.75	0.000**

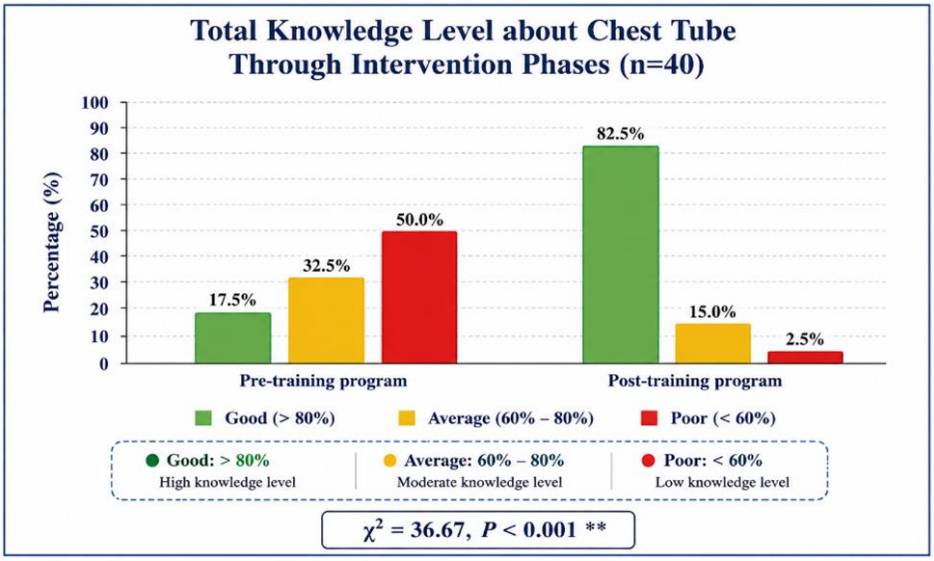


Figure (1): The Effect of the training program on total scores of chest tube knowledge as reported by the studied nurses (n=40).

Table (4): The Effect of the training program on Total scores of chest tube practice **(n=40).**

Subtotal items of practice related to care of infants with chest tube	Pre-training program				Post-training program				X^2	P-value
	Satisfactory		Unsatisfactory		Satisfactory		Unsatisfactory			
	No.	%	No.	%	No.	%	No.	%		
Pre-assessment for chest tube insertion	30	75.0	10	25.0	37	92.5	3	7.5	4.27	0.039*
infant preparation	30	75.0	10	25.0	38	95.0	2	5.0	6.27	0.012*
Practices related to chest tube procedure	25	62.5	15	37.5	36	90.0	4	10.0	8.40	0.004**
Assess drainage system patency	28	70.0	12	30.0	38	95.0	2	5.0	9.14	0.003**
Changing dressing for the site of chest tube insertion	31	77.5	9	22.5	39	97.5	1	2.5	7.19	0.007**
Assessment for signs that reveal lung expansion and preparation for chest tube removal	31	77.5	9	22.5	39	97.5	1	2.5	7.19	0.007**
Infant assessment after removal of chest tube	30	75.0	10	25.0	39	97.5	1	2.5	8.44	0.004**
Documentation	28	70.0	12	30.0	38	95.0	2	5.0	9.14	0.003**
Safety management	33	82.5	7	17.5	39	97.5	1	2.5	5.37	0.021*

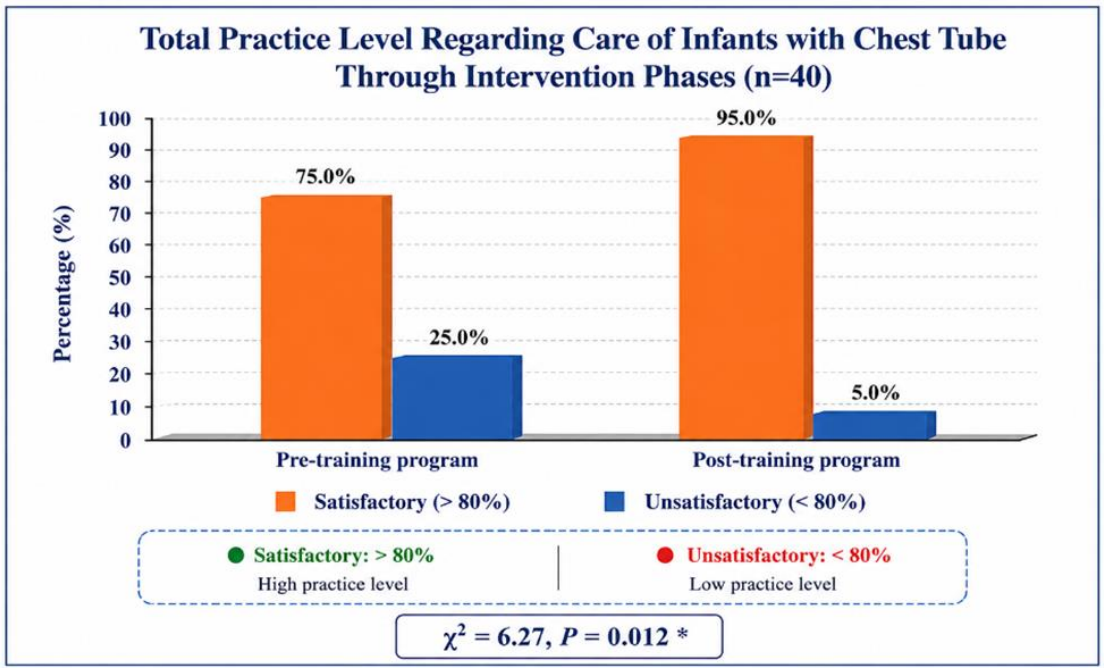


Figure (2): The Effect of the educational program on Total scores of chest tube practice throughout the study phases (n=40).

Table (5): Personal characteristics of the studied infants' (n=60)

Personal characteristics	Case group (n=30)		Control group (n=30)	
	No.	%	No.	%
Infant's age				
0 - ≤ 28 days	12	40.0	10	33.3
28 days - ≤ 3 months	9	30.0	11	36.7
3 - ≤ 6 months	5	16.7	6	20.0
6 - ≤ 9 months	3	10.0	2	6.7
9 - ≤ 12 months	1	33.3	1	3.3
Mean±SD	**2.63±2.65 months**		**2.64±2.46 months**	
Gender				
Male	16	53.3	17	56.7
Female	14	46.7	13	43.3
Infant's weight				
Mean±SD	**5.95±0.91**		**5.83±1.04**	

Table (6): clinical data of the studied infants with chest tube **(n=60)**

Medical history	Case group (n=30)		Control group (n=30)	
	No.	%	No.	%
Initial diagnosis of the infant				
Respiratory distress syndrome	7	23.3	8	26.7
Meconium aspiration syndrome	2	6.7	1	3.3
Congenital pneumonia	2	6.7	2	6.7
Congenital diaphragmatic hernia	1	3.3	1	3.3
Pneumonia	11	36.6	10	33.3
Bronchitis	5	16.7	6	20.0
Congenital heart disease	2	6.7	2	6.7
Reasons for chest tube insertion				
Pneumothorax	18	60.0	16	53.3
Pleural effusion/empyema	9	30.0	11	36.7
Post-operative drainage	3	10.0	3	10.0
Length of hospital stay				
3- ≤ 7 days	4	13.3	5	16.7
7- ≤ 14 days	13	43.3	12	40.0
14 - ≤ 30 days	10	33.3	10	33.3
30 days - ≥	3	10.0	3	10.0
Number of chest tubes connected to the infant				
One tube	26	86.7	26	86.7
Two tubes	4	13.3	4	13.3
Site of chest tube in the infant				
Right lung	16	53.3	15	50.0
Left lung	11	36.7	12	40.0
Both	3	10.0	3	10.0
Duration of chest tube connection				
≤ 5 days	22	73.3	14	46.7
> 5 days	8	26.7	16	53.3

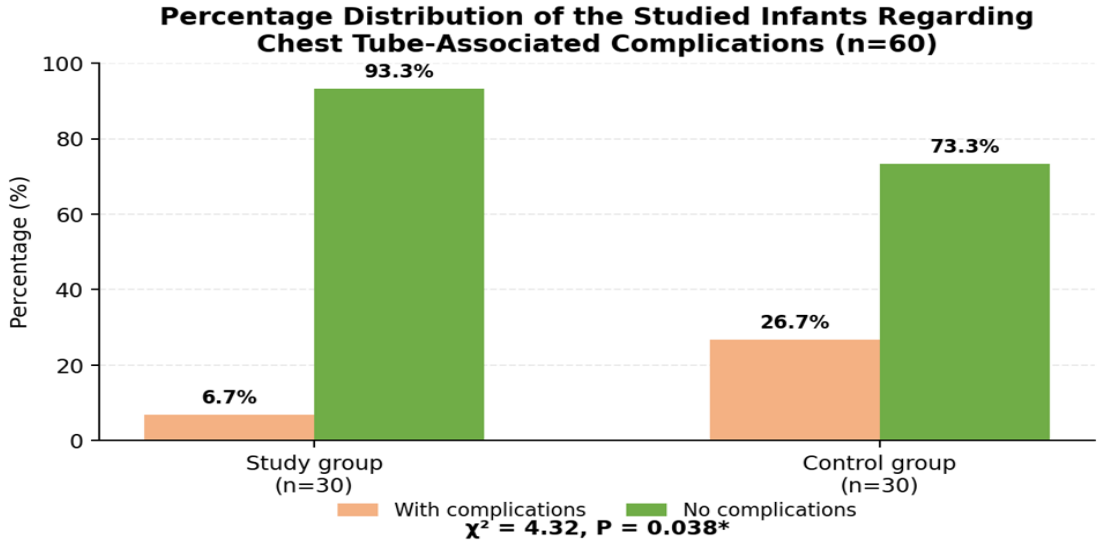


Figure (3): The Effect of the educational program on chest tube complications of the studied infants through the study phases (n=60)

Table (7): Relation between nurses' total knowledge level (n=40) and chest tube-associated complications among infants (n=60)

knowledge level	Study Group (n=30)				Control Group (n=30)				χ^2	P-value
	With Complications		Without Complications		With Complications		Without Complications			
	No.	%	No.	%	No.	%	No.	%		
Good	3	10.0	22	73.3	9	30.0	15	50.0	6.89	0.009**
Average	4	13.3	1	3.3	3	10.0	2	6.7	1.02	0.313
Poor	0	0.0	0	0.0	1	3.3	0	0.0	0.58	0.446

Table (8): Correlation Matrix between Nurses' Total Knowledge Score, Total Practice Score, and Chest Tube-Associated Complications (N = 40)

Variables			Total Knowledge Score		Total Practice Score		Complications	
			Pre	Post	Pre	Post	Pre	Post
Total Knowledge Score	Pre	r						
		p-value						
	Post	r	0.512**					
		p-value	0.001					
Total Practice Score	Pre	r	0.412*	0.523**				
		p-value	0.008	0.001				
	Post	r	0.438**	0.823**	0.498**			
		p-value	0.005	< 0.001	0.001			
Complications	Pre	r	-0.234	-0.312	-0.187	-0.245		
		p-value	0.147	0.051	0.249	0.129		
	Post	r	-0.342*	-0.742**	-0.368*	-0.768**	0.425**	
		p-value	0.031	< 0.001	0.019	< 0.001	0.006	

Discussion:

Chest tube drainage is a critical intervention in neonatal and pediatric care, requiring nurse to maintain drainage-system integrity, monitor respiratory status and recognize potential complication promptly. These responsibilities highlight the importance of adequate nursing knowledge and practice competences in providing safe chest tube care (Davis et al., 2024).

Previous research has identified gaps in nurses' knowledge of chest tube monitoring and ongoing care, highlighting the need for structured educational interventions (Aktaş et al., 2024). Evaluating such interventions is particularly relevant in neonatal and pediatric settings, where safe chest tube management requires consistent knowledge and practice skills.

The present study was conducted to evaluate the effect of a training program on nurses' knowledge and practices regarding care of infants with chest tubes and associated clinical outcomes.

Regarding nurses' total knowledge of chest tube care, the present study revealed highly statistically significant improvements in the four knowledge domains (knowledge about chest tubes, during chest tube

insertion, after chest tube insertion and removing a chest tube) following the training program. Before training, less than one quarter of the nurses had good knowledge in each domain, compared with more than three quarters afterward. Knowledge after chest tube insertion had the highest post-training proportion of good scores. This improvement may be attributed to the structured and sequential nature of the training program, which provided nurses with organized information about chest tube indications, insertion, routine care and removal, combined with explanation of nurses' responsibilities when caring for infants. Moreover, presenting the information in a systematic manner may have facilitated the integration of new knowledge with nurses' previous clinical experiences.

This finding agrees with Shaker et al. (2024), who conducted the Egyptian study entitled "Effect of Educational Guidelines Application on Nurses' Performance Caring for Patients Undergoing Chest Tube" and documented improvement in chest tube knowledge after educational guidelines. Similarly, Aktaş et al. (2024), in the Turkish study entitled "Knowledge Levels of Pediatric Nurses Regarding the Care of Patients with Chest Tubes," found higher knowledge among nurses with previous chest tube training. This also supports the importance of targeted pediatric chest tube education.

This result goes in line with another Egyptian study entitled "Effect of Educational Intervention on Nurses' Performance Regarding Care of Critically Ill Children with Pneumothorax". (Abdel-Mohsen et al. 2023), among 100 nurses, the proportion of nurses with good knowledge increased from a very small proportion before the intervention to the vast majority after the intervention.

On the other hand, Salimian et al. (2024), reported a different baseline knowledge among the studied nurses working in hospitals in Ardabil, Iran, regarding the care for patients with chest tube. Reported predominantly moderate knowledge despite satisfactory practice in most nurses.

Regarding the total level of nurses' knowledge of chest tube care, the current study revealed that less than one fifth of the studied nurses before training had good knowledge. Following the program, the great majority achieved good knowledge with a highly statistically significant difference. Giving information in a structured and repeated manner in the training program helped nurses to retain knowledge and develop a clearer understanding of the rational behind each nursing intervention. This also facilitated the integration of new knowledge with nurses' previous clinical experiences.

This result is supported by Ullah et al. (2024), who reported significant improvement in nurses' chest drainage knowledge following a demonstration-based training intervention on management of chest tube among nurses in Pakistan.

Regarding nurses' practice in caring for infants with chest tubes, the present study showed statistically significant improvements in assessed practice domains after training. Satisfactory practice ranged from nearly two thirds to more than four fifths before training and rose to the great majority afterward. Demonstrating the correct procedure during the training program, which allowing nurses to observe the required steps and providing opportunities for practice may have enhanced procedural confidence, reduced uncertainty and prompted more consistent application of recommended nursing practices.

Kouser et al. (2023), who studied the effect of chest drain management guidelines on knowledge and practice among nurses at services hospital in Pakistan support the findings of the present study and reported significantly improved chest drain knowledge and observed practice after guidelines-based education. Likewise, Shaker et al. (2024) also reported improvement in nurses' chest tube-related performance following structured educational guidelines in Egypt.

On the other hand, Nguyen et al. (2024), in the Vietnamese study "Nursing Care for Patients With Open Thoracostomy: Case Series Report and Proposal for Standardized Care Protocol," noted that documentation and reporting improved only slightly and not significantly after a short training intervention, despite marked improvement in other practical skills.

Concerning the total practice level regarding chest tube care, the current study revealed that three quarters of the studied nurses had satisfactory practice before training, increasing to the vast majority of them after the program, with a statistically significant difference. The improvement in nurses' practice may be attributed to the opportunity to translate theoretical knowledge into observable clinical actions through practical demonstration and supervised application. As chest tube care involves psychomotor skills that

cannot be fully developed through theoretical instruction alone.

This finding is supported by Mahmoud et al. (2023), who studied effect of educational guidelines on nurses' performance for caring of critically ill patients with digital chest drainage system in Egypt. They reported significant post-guideline improvement in nurses' performance, although some of the improvement declined at follow-up.

Similarly, Abdel-Mohsen et al. (2023), in their study, reported that competent nursing practices increased from nearly one-quarter before the educational intervention to the vast majority afterward. This agrees with the improved practice level observed after the present training program.

Conversely, Sayed (2022) reported good chest tube nursing practice among most participating intensive-care nurses despite only average knowledge scores. This different baseline pattern indicates that the distribution of satisfactory practice may be shaped by local routines and clinical exposure. It also cautions against assuming that every setting starts with the same practice gaps or that a common satisfactory threshold can be compared directly across distinct checklists. secure connections, prevention of kinks and routine bedside checks. Neither source directly quantified infant complications according to nurse practice scores; rather, both support plausible mechanisms of safer chest drainage care which recommendrd by Royal Children's Hospital (2022) nursing guideline.

Regarding chest tube-associated complications among infants, the current study showed that more than one fifth of infants in the study group experienced complications, compared with more than two fifths in the control group. However, the overall difference was not statistically significant. The absence of statistically significant difference in the overall complications rate between the study and control groups, despite the observed numerical reduction in the study group, may be related to multifactorial nature of chest tube associated complications. The occurrence of such complications not only influenced by nursing care but also by the underlying clinical condition, severity of illness, indication of chest tube insertion, insertion technique, and patient related factors. Therefore improvement of nursing knowledge and practice doesn't necessarily associate in significant reduction in all complications.

In a related neonatal population, Baudat-Nguyen et al. (2024) reported a measurable burden of complications following chest tube drainage for pneumothorax in Switzerland. Their retrospective study compared clinical drainage strategies, not trained versus untrained nurses. Thus, it demonstrates that chest tube outcomes can vary with treatment context and infant condition, but does not directly oppose or confirm the present training-related findings.

The present study supported by Sutasir et al. (2024), in Türkiye, which, additional evidence suggests that chest tube complications have multiple causes reported that identified younger age, traumatic etiology and general anesthesia as independent predictors of pediatric complications.

The finding is agree with the results of the study Abdel-Mohsen et al. (2023) which revealed that there were no statistically significant differences in several chest-tube-associated complications following the educational intervention, including improper water-reservoir filling, chest tube twisting, and accidental tube removal.

Regarding the relationship between nurses' knowledge level and chest tube-associated complications, showed that nearly three quarters of infants in the study group had no complications within the good-knowledge category, compared with half of infants in the control group. The Results of the present study reveals this comparison as statistically significant, while comparisons for average and poor knowledge were reported as non-significant. The observed relationship between nurses' adequate knowledge; nevertheless alone may not be sufficient to prevent complications unless translated into effective clinical practice.

Regarding the relationship between nurses' practice and chest tube-associated complications, showed that nearly three quarters of infants in the study group had no complications within the satisfactory-practice category, compared with slightly more than half in the control group. The present study shows that a significant comparison, whereas the unsatisfactory-practice comparison was reported as non-significant. This may be due to satisfactory practice after implementation of the training program may promote secure

drainage connections and early recognition of problems.

Royal Children's Hospital (2022) nursing guideline recommending secure connections, prevention of kinks and routine bedside checks. Neither source directly quantified infant complications according to nurse practice scores; rather, both support plausible mechanisms of safer chest drainage care.

Concerning the correlation between nurses' total knowledge and practice regarding chest tube care, the present study showed a statistically significant positive correlation between nurses' total knowledge and practice regarding chest tube care before and after implementation of training program, which became stronger afterward. Integrating explanations with demonstrations and supervised practice may have helped nurses translate greater understanding into more consistent care. Nevertheless, a correlation alone cannot establish that increased knowledge caused improved clinical practice.

This finding is in agreement with Shaker et al. (2024), who reported a highly statistically significant positive relationship between nurses' chest tube knowledge and practice scores. It is also compatible with Salimian et al. (2024), who found a significant positive, although weak, correlation between these variables in Iranian hospitals.

In contrast, Sayed (2022), studying chest tube nursing management in India, reported no statistically significant correlation between nurses' knowledge and practice. It indicates that stronger knowledge does not invariably correspond to higher observed practice without organizational and practical supports.

Regarding the correlations between nurses' knowledge, practice and chest tube-associated complications, the finding of the present study revealed negative correlations of post-training complications with knowledge and practice. Higher nursing performance may accompany more timely recognition of drainage problems.

In a related pediatric chest tube education initiative in the United States, Davis et al. (2024) educational intervention improve nurses' knowledge, readness for safe care and confidence in chest tube management.

Overall, the findings of the present study demonstrated that the implementation of a structured training program had a positive impact on nurses' knowledge and practical performance regarding the care of infants with chest tubes. The improvements in nurses' knowledge and practice, along with the significant positive correlation between these two variables, emphasize the importance of integrating theoretical information with practical training and supervised clinical application. Although the overall reduction in chest tube-associated complications among infants in the study group did not reach statistical significance, the observed differences suggest a potential benefit of improved nursing performance in promoting safer chest tube care. Therefore, continuous nursing education, regular clinical supervision, and adherence to standardized chest tube management guidelines are essential to maintain nurses' competencies and enhance the quality and safety of care provided to infants with chest tubes.

Conclusion

Based on the findings of the present study, it can be concluded that nurses' knowledge and practices regarding the care of infants with chest tubes improved substantially following implementation of the training program. Before the program, half of the studied nurses had poor total knowledge, whereas after the program the great majority demonstrated good knowledge. Furthermore, satisfactory total practice increased from three quarters of the nurses before training to the great majority after training. The relationship between knowledge and practice was positive and statistically significant in both assessments and became markedly stronger after training. Regarding infants' outcomes, chest tube-associated complications were recorded in less than one quarter of the study group compared with more than two fifths of the control group. Higher post-training nursing knowledge and practice scores were negatively associated with recorded complications, supporting the importance of continuing clinical education and consistent nursing surveillance.

Recommendation

Based on the findings of the current study, the following recommendations are suggested:

1. Periodic in-service educational programs should be provided for neonatal and pediatric intensive care nurses to reinforce current knowledge about chest tube indications, drainage systems, insertion assistance, ongoing monitoring and safe removal-related care.

2. Structured practical workshops and simulation sessions should be organized to improve nurses' performance in securing chest-tube connections, maintaining underwater-seal systems, recognizing obstruction or leakage and responding promptly to accidental disconnection or displacement.
3. Regular bedside competency assessments and direct observational checklists should be implemented for chest tube care before, during and after insertion, as well as for dressing changes, documentation and infant assessment following removal.
4. Focused refresher sessions should address areas of weaker pre-training performance, particularly recognition of the safe triangle, selection of appropriate equipment, chest drainage monitoring, system patency, tube position and detailed documentation.
5. Standardized unit-based guidelines and readily accessible chest-drain care protocols should be maintained, with explicit directions for aseptic technique, drainage-container positioning, handover, escalation of respiratory deterioration and preparation for transfer.
6. Nurse managers and clinical educators should provide supportive supervision, clinical feedback and recurring reassessment to help sustain improvements in knowledge and practices beyond the immediate post-training period.
7. Nursing and medical teams should collaborate in the early detection, reporting and management of complications such as drainage-system disconnection, tube twisting, leakage, blockage, accidental removal, persistent pneumothorax and insertion-site infection.
8. Infants who require prolonged chest tube drainage or mechanical ventilation should receive intensified monitoring and coordinated multidisciplinary review because these factors were associated with higher complication odds in the reported analysis.
9. Quality-improvement activities should routinely track overall and individual chest tube-associated complications, document relevant clinical characteristics, and distinguish statistically significant outcomes from non-significant overall comparisons.
10. Further multicenter studies with larger infant samples, appropriate comparison groups and longer follow-up should evaluate the sustainability of nursing performance gains and whether educational interventions reduce overall chest tube-associated complication rates.
11. Establish evidence-based institutional guidelines for infant chest tube management and evaluate their implementation and impact on nursing practices and patient safety.
12. Examine the role of digital learning technologies, including online educational modules and interactive learning platforms, in improving access to training and supporting nurses’ ongoing professional development.
13. Conduct studies examining specific chest tube-associated complications separately, using clearly defined clinical criteria and adequate sample sizes, to determine whether educational interventions are associated with reductions in particular complications.
14. Replicate the present study in different geographical regions and healthcare systems to identify contextual differences and develop training programs tailored to the educational needs of nurses and the clinical requirements of infants with chest tubes.
15. Explore factors influencing nurses’ compliance with chest tube care protocols, including workload, staffing levels, years of experience, previous training, availability of equipment, and institutional support.

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