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EFFECT OF FOOT REFLEXOLOGY VERSUS CRYOTHERAPY ON PAIN ASSOCIATED WITH ARTERIAL PUNCTURE AMONG CRITICALLY ILL CHILDREN

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Abstract: **Arterial puncture is one of the most frequently performed invasive painful procedures in Pediatric Intensive Care Unit (PICU) for arterial blood gas analysis. So, non-pharmacologic pain relieving strategies as foot reflexology and cryotherapy should be used as an effective and safe way to relieve critically ill children's pain. This study aimed to determine the effect of foot reflexology versus cryotherapy on pain associated with arterial puncture among critically ill children. Setting: The study was conducted at the PICUs at Smouha Children's University Hospital and El- Ramel Children's Hospital (Wengat). Subjects: A convenience sampling of 90 critically ill children and randomly assigned into three equal groups namely; foot reflexology, cryotherapy and control groups. Tools: Three tools were used namely; critically ill children's physiological parameters measurement record, Pediatric Glasgow Coma Scale (PGCS) and COMFORT-Behavioral response scale. Results: The study findings revealed that severe pain was noticed among 26.7% of the critically ill children in the control group compared to none of those in either the cryotherapy group or the foot reflexology group during the puncture. Statistical significant differences were found between the control and cryotherapy groups, as well as between the control and foot reflexology groups either during or immediately after the arterial puncture (P= 0.000 for each). Conclusion: It can be concluded that foot reflexology and cryotherapy were effective in reducing critically ill children's pain during and immediately after arterial puncturing procedure. Furthermore, critically ill children who received foot reflexology experienced less pain than those who received cryotherapy. Recommendations: Non-pharmacological pain relieving measures for critically ill children particularly foot reflexology and cryotherapy interventions should be incorporated in PICUs policies. Pediatric critical care nurses should be encouraged to apply foot reflexology and cryotherapy interventions to reduce critically ill children's pain associating with arterial puncturing procedure.**

Keywords: **Critically Ill Children - Arterial Puncturing - Pain – Cryotherapy- Foot Reflexology.**

1. INTRODUCTION

Critically ill children are those children with life threatening illness or injury that requires urgent admission to the Pediatric Intensive Care Unit (PICU) to guarantee their survival {Madkour, 2016 #438}. Respiratory illnesses are still the most common diagnoses among those children. Deaths of critically ill children in hospital often occur within the first 24

hours of admission that could be prevented if critically ill children were identified and appropriate treatment was started immediately upon their arrival at hospital (World Health Organization [WHO], 2016). Globally, according to WHO, (2017) 5.6 million children under age five years died in 2016, mostly from preventable causes such as pneumonia, diarrhea and malaria.

Critically ill children undergo a wide variety of painful invasive diagnostic and therapeutic procedures during their staying in PICU such as chest tube insertion, lumbar puncture, intravenous cannulation and arterial puncture (Hockenberry & Wilson, 2015). Arterial puncture is one of the most frequently performed invasive procedures in PICU for Arterial Blood Gas (ABG) analysis which provides useful information regarding respiratory and metabolic pathology. Arterial blood sampling can be obtained from different sites namely; radial, brachial, ulnar, dorsalis pedis, axillary, posterior tibial and femoral arteries (Zinchenko, Prinsloo, Zarafov, Grzesiak, & Cohn, 2016).

Puncturing of the radial artery is the most common and the preferred method of obtaining an arterial blood sample due to its good collateral circulation, superficial location and easily accessibility which makes it compressible for hemostasis (Dev, Hillmer, & Ferri, 2011; Reichman, 2013). Arterial puncture is painful and worrisome procedure experienced by critically ill children as it has high innervation levels and requires a deeper needle insertion. Additionally, it is worsened on repeated attempts to obtain successful sample (Hudson, Dukes, & Reilly, 2008). Moreover, it is more painful particularly for children who need frequent analysis of ABG to assess their respiratory and metabolic functions (Zinchenko et al., 2016). The American Pain Society (APS) (2015), considered pain as the fifth vital sign and recommended that effective management of pain in children requires a cyclical approach of assessment, intervention, and reassessment (Haynes, 2015).

Accurate pain assessment in children is difficult to be achieved. Three main methods are currently used to assess pain intensity include self-report, behavioral, and physiological indicators. Self-report measures are optimal and the most valid, but both verbal and nonverbal indicators require a certain level of cognitive and language development for the child to understand and give reliable responses. So, observed physiological and behavioral responses of pain provide helpful information, particularly for younger children where communication is difficult (Hockenberry & Wilson, 2015).

Physiological responses include assessment of heart rate, blood pressure, respiration, oxygen saturation, palmer sweating, and sometimes neuro-endocrine responses. While, behavioral responses consist of assessment of crying, facial expressions, body postures, and movements (Srouji, Ratnapalan, & Schneeweiss, 2010). In addition, there are a numerous pediatric pain scales, such as, Alertness, Calmness/Agitation, Respiratory response/Crying, Physical movement, Muscle tone, and Facial tension (COMFORT-Behavior Scale [COMFORT-B scale]) scale. It is the most valid and reliable behavioral pain assessment tool, which had been developed for children in critical care settings (Boerlage et al., 2015). Pain in critically ill children is often unappreciated due to the inability of some of those children to communicate their pain because of age varieties and disturbed level of consciousness (Oakes, 2011).

Relief of pain is a basic need and right of all children because unrelieved pain may lead to potential detrimental long-term physiological, psychosocial, and behavioral consequences (Hockenberry & Wilson, 2015). Basically, pain management strategies can be grouped into two categories, non-pharmacological and pharmacological (Alalo, Ahmad, & Sayed, 2016). Several pharmacological interventions have been developed to manage children's pain. However, the American Academy of Pediatrics (AAP) recommended using of non-pharmacological ones (Kahsay, 2017). A number of non-pharmacological strategies, such as cryotherapy and reflexology can help with pain control (Vadivelu, Urman, & Hines, 2011).

Cryotherapy is a simple, non-invasive, safe and an inexpensive nursing intervention among non- pharmacological strategies for pain control (Davtalab, Naji, & Shahidi, 2016). It is a cutaneous stimulation method among children as the precooling of a puncture site with ice reduces the velocity of nerve conduction in C- and A-delta fibers. Consequently, it will slow the transmission of pain signals, increasing the pain threshold and providing partial or complete anesthesia or numbness of the selected area of skin (El-said, Ouda, Mahmoud, & El-Sadek, 2017). So, it can be used to reduce pain associated with arterial puncture among critically ill children.

Foot reflexology is an approved ancient complementary non-pharmacological approach for minimizing pain (Nourse, 2012; Özdemir, Ovayolu, & Ovayolu, 2013). It is a system of hand techniques that apply pressure to reflex points and areas in the feet, hands, ears and face as depicted on reflexology map. Reflexology is a gentle massage therapy that

encourages the body to work naturally to restore its own balance (Kaur, Kaur, & Bhardwaj, 2012; Sheikh, Yaghoubinia, & Navidian, 2017) .It aims to achieve free flow energy in various organs and cells associated with pressure points, and in the entire body. Therefore, it accelerates blood circulation and helps the body to maintain homeostasis (Embong, Soh, Ming, & Wong, 2015).

Care of critically ill children during painful procedures such as arterial puncture is an exciting challenge for pediatric critical care nurses (Hockenberry & Wilson, 2015). Therefore, they have a pivotal role in pain assessment, management and prevention in order to prevent its adverse effects. Pediatric critical care nurses should use cryotherapy and foot reflexology in an effective and safe manner to relieve critically ill children pain (Embong et al., 2015; Haynes, 2015). Researches addressing the incorporation of these non-pharmacological strategies in PICU during painful procedures are limited. Hopefully, the present study would apply the non-pharmacological pain management strategies that could decrease pain among critically ill children in PICU.

Aim of the Study

This study aimed to determine the effect of foot reflexology versus cryotherapy on pain associated with arterial puncture among critically ill children.

Research Hypothesis:

Critically ill children who receive foot reflexology during arterial puncture exhibit less pain than those who receive cryotherapy.

2. MATERIALS AND METHOD

Materials

Design: Quasi experimental research design was used.

Settings: The study was conducted in Pediatric Intensive Care Units (PICUs) at Smouha Children's University Hospital and El-Raml Children's Hospital (Wengat) in Alexandria:

Subjects: A convenience sampling of 90 critically ill children who admitted to the previously mentioned settings and fulfilled the following criteria comprised the study subjects: Age ranged from 3-6 years, Recruited for arterial puncture, Foot was free from any problem to conduct foot reflexology as wound, allergy, injury and pain, and Conscious critically ill children with Glasgow Coma Scale ranged from 13- 15 points.

Epi-Info program was used to estimate the subject size; the minimal sample size was estimated to be 86. The research sample consisted of 90 critically ill children for better results and statistical analysis. Epi-Info program was based on the following: Population size = 110 critically ill children, the expected frequency=50%, the acceptable error=10% and the confidence coefficient =95%

Critically ill children were randomly assigned into three equal groups; each group consisted of 30 critically ill children as follows:

- **Foot Reflexology Group**: critically ill children who received foot reflexology before and throughout the arterial puncture procedure beside routine PICU care as a study group.
- **Cryotherapy Group:** critically ill children who received cryotherapy for three minutes immediately before arterial puncture procedure beside routine PICU care as a study group.
- **Control Group**: critically ill children who received the routine PICU care during arterial puncture.

Tools:

Three tools were used to collect the necessary data.

Tool I: Critically Ill Children's Physiological Parameters Measurement Record:

This tool was developed by the researcher to identify the physiological parameters of critically ill children who were undergone arterial puncture in PICU. It included two parts:

– **Part I: Critically Ill Children's Characteristics:** such as; child's age, gender, diagnosis, site of arterial puncture and number of trials.

– **Part II: Critically Ill Children's Physiological Parameters:** It included respiratory rate, heart rate and oxygen saturation (Spo2).

Tool II: Pediatric Glasgow Coma Scale (PGCS):

This scale was developed by (Hockenberry & Wilson, 2015) to assess the critically ill children's level of consciousness. This scale comprised of three-part assessment: eye opening, as well as verbal and motor responses. Responses to eye opening were scored by using 4-point Likert scale ranged from 1 to 4 as follows: spontaneous eye opening (4), to speech (3), to pain (2) and none (1). Responses to verbal test were scored by using 5-point Likert scale ranged from 1 to 5 as follows: oriented (5), confused (4), inappropriate words (3), incomprehensible words (2), and none (1). While, responses to motor test were scored by using 6-point Likert scale ranged from 1 to 6 as follows: obeys commands (6), localizes pain (5), flexion withdrawal (4), flexion abnormal (3), extension to pain (2), and none (1). The total scores of PGCS ranged from 3 to15 points and were ranked as follows:

- PGCS from 3 to 8 points→ Coma.
- PGCS from 9 to 12 points →Semi-conscious.
- PGCS from 13 to 15 points →Conscious.

Tool III: COMFORT-Behavioral Response Scale:

The COMFORT-behavioral response scale was derived from the original COMFORT scale which was developed by (Ambuel, Blumer, Hamlett, & Marx, 1992). It was modified by (Dijk, Peters, Deventer, & Tibboel, 2005) by adding an item which was crying that was used to assess pain in non-mechanically ventilated critically ill children and two physiological parameters namely; heart rate and blood pressure were deleted. The researcher used this scale to assess the critically ill child's behavioral response to pain in PICU. It comprised of six behavioral categories namely; alertness, calmness–agitation, respiratory response or crying, physical movement, muscle tone, and facial tension. Responses to each category in this scale were scored by using 5-point Likert scale ranged from 1 to 5 with distinct behavioral descriptions. The total score of this scale ranged from 6 to 30 and scores of ≥17 indicate pain and requires an intervention (Boerlage et al., 2015). So, the total score was ranked as follows:

- 6 to 16 → No pain.
- 17 to 21→ Mild pain.
- 22 to 26 →Moderate pain.
- 27 to 30 → Severe pain (the greatest possible pain).

Method

1. An official approval for conducting the study was obtained from the directors of the PICUs of Smouha Children's University Hospital and El- Ramel Children's Hospital (Wingat) after explaining its aim.

2. Tool I was developed by the researcher.

3. The researcher received a training course in massage and reflexology by two professors' expert in reflexology at Biological Science and Sport Health Department, Faculty of Sport Education for Men (Physical Fitness and Sport for All Unit), Alexandria University. The training course included 40 credit hours during March 2018.

4. A pilot study was carried out on nine critically ill children (10% of sample size) from the previously mentioned settings to test the feasibility, applicability and clarity of the research tools. Accordingly, a necessary modification was done which was identifying the source of oxygen from critically ill children. These critically ill children were excluded from the total study subjects.

5. The level of consciousness was estimated for every critically ill child in the PICUs in order to select the study subjects by using tool II (PGCS).

6. Characteristics of critically ill children were obtained from children's medical records for each subject in the study by using tool I (part I).

7. Physiological parameters were measured and recorded before arterial puncture procedure for the three groups by using tool I (part II).

8. As a baseline data, assessment of pain was done before arterial puncture procedure for the three groups by using tool III.

9. **For Foot Reflexology Group:**

Foot reflexology was performed for 20 minutes before and throughout the arterial puncture procedure for both feet. Foot reflexology was performed on the right foot for ten minutes, then on the left foot in the same manner beside routine PICU care.

The foot reflexology technique was done as follows:

- **Preparation Phase:**

- The researcher was examined the critically ill child's legs for any wound, pain, and allergy.
- The researcher reassured the critically ill child that reflexology is a safe technique.
- The critically ill child was put in semi fowler's position. A pillow was placed under the child's leg to support it.
- The researcher sat in a quite comfortable and relaxed position in front of the child's leg. After that, the researcher applied a small amount of non-therapeutic baby lotion on her hands to facilitate massaging and minimize skin friction.

- **Warm-Up Phase:**

- Pre-reflexology foot massage and all over foot squeeze were performed for two minutes.

- **Traction**: the background movements from the lower leg to the ankle, sole, back, and the toes were massaged simply using the palm and fingers of one hand, the foot was hold firmly, the researcher pulled it gently and gradually toward him, the foot was hold for 10-15 seconds then released. This technique was repeated several times.
- **Rotation Ankle**: the ankle was turned around several times while the heel was supported by one hand.

- **Mini-Reflexology Session:**

- Specific reflexology was performed with special attention to four important foot reflex areas that included:

- **Diaphragm & solar plexus reflex areas** which are located in the distance between the upper and middle third of the sole. It can enhance the function of the diaphragm muscle and the nerve network of the solar plexus, both of which are involved in respiration and many other involuntary body functions.
- **The pituitary reflex area** that is located in the middle of the big toe. Pituitary gland working with this gland can benefit body activities such as metabolism.
- **The heart and lung reflex areas** are located below the chest of the foot. Heart pumps the oxygen-rich blood around the body.

Step 1: Reflexology for Diaphragm &Solar plexus reflex area by using thumb-walking technique for about two minutes.

- The goal of the thumb-walking technique was to apply a constant, steady pressure to the surface of the foot.

- The basic movement in thumb-walking was the bending and unbending of the first thumb joint, below the researcher's thumbnail. It aimed to move the thumb across the skin in small "bites," and to create a feeling of constant as well as steady pressure.

1. The left hand was used to hold the toes back. The researcher started with the diaphragm reflex area, the right thumb was used to thumb-walk up through the heart and chest reflex areas toward the toes. Several passes were made over this broad area.

2. The thumb was repositioned on the solar plexus reflex area. The same technique was used as before, several passes up were made over this tiny area.

Step 2: Reflexology for Pituitary gland reflex area:

The big toe was hold with holding hand. The working thumb was rested just above the pituitary gland reflex area. The researcher hooked in with the thumb and pulled back across the reflex area which was repeated for about two minutes.

Step 3: Reflexology for Lung reflex area in the ball of the foot by using lung-press technique (one hand pushed and the other hand responded with a gentle squeeze) for about two minutes.

1. The left hand was formed into a fist. The flat of the fist was rested against the ball of the foot. The top of the foot firmly was hold with the right hand and pushed with the fist.

2. After that, it was squeezed gently with the right hand. A rhythmic push/squeeze pattern was builded up as the researcher repeated the actions several times (Embong et al., 2015; Sheikh et al., 2017; Yaghoubinia, Navidian, Sheikh, Safarzai, & Tabatabaei, 2016).

- **Finishing Phase:** for about two minutes

- The thumb was placed on the solar plexus reflex area of each foot.

- The palms of hands were pressed against the soles of the feet, after the both feet were massaged.

10. **For Cryotherapy Group:**

- The researcher prepared three-to-four pieces of frozen distilled water in a plastic bag.

- The small ice bag was wrapped with towel and applied on the selected site for three minutes immediately before arterial puncture procedure and was removed immediately before the arterial puncture beside routine PICU care.

11. **For Control Group:** Every critically ill child received the routine PICU care before arterial puncture procedure.

12. Physiological parameters were measured and recorded during and immediately after arterial puncture procedure for the three groups by using tool I (part II).

13. Pain was assessed throughout the arterial puncture procedure and immediately after the procedure for the three study groups using tool III.

14. Comparison between findings of the three study groups were done to determine the effect of foot reflexology versus cryotherapy on pain associated with arterial puncture among critically ill children.

15. Data were collected over a period of six months starting from September 2018 to the end of February 2019.

16. **Ethical Considerations:**

- Written informed consents were obtained from the critically ill children's guardians after explaining the aim of the study and their right to refuse to participate in the study or to withdraw at any time was considered.

- Critically ill children's confidentiality of the collected data and privacy were maintained during implementation of the study.

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Statistical Analysis:

- The collected data were coded and transferred into specially designed formats to be suitable for computer feeding. Following data entry, checking and verification processes were carried out to avoid errors encountered during data entry. Frequency analysis, cross tabulation and manual revision were all used to detect any errors. The Statistical Package for Social Sciences (SPSS version 22) was utilized for both data presentation and statistical analysis of the results.
- Microsoft office Excel software was used to construct the needed graphs.

The following statistical measures were used:

- **Descriptive Statistics:**

1. Number and percentage were used for describing and summarizing qualitative data.
2. Minimum, maximum, mean and standard deviation (**SD**) were used for describing and summarizing quantitative data.

- **Analytical Statistics:**

1. Kolmogorov – Smirnov test was used to examine the normality of data distribution
2. Chi-square test and Monte Carlo test were used to test the significance of results of qualitative variables.
3. Comparison of pain level among the three groups using Chi-Square Test (χ^2) for comparison of sample proportion.
4. The 0.05 level was used as the cut off value for statistical significance (significant at $P \leq 0.05$).

3. RESULTS

Table 1 presents the characteristics of the critically ill children. It was revealed from the table that ages of critically ill children in the control group, the cryotherapy group and the foot reflexology group were three to less than four years (56.7% 66.7% and 53.3% respectively). Their mean ages were 3.63±0.809, 3.50±0.777 and 3.67±0.802 respectively. Male critically ill children constituted 60.0%, 50.0% and 53.3% among the control group, the cryotherapy group and the foot reflexology group respectively. Concerning their diagnosis, it was obvious that nearly two thirds of the critically ill children were diagnosed with bronchial pneumonia in the control group, the cryotherapy group and the foot reflexology group (63.4%, 66.6% and 60.0% respectively).

The same table clarified that the femoral artery is the most common selected site for arterial puncture among critically ill children of the control group, the cryotherapy group and the foot reflexology group (83.3%, 93.3% and 80.0% respectively). As regards number of trials, it was found that 66.7%, 63.3% and 70.0% of the critically ill children were experienced only one trial for obtaining successful arterial blood sampling in the control group, the cryotherapy group and the foot reflexology group respectively.

Table 2 shows the effect of cryotherapy and foot reflexology on heart rate during arterial puncture among critically ill children. Before arterial puncture, the table clarified that 60.0%, 56.7% and 53.3% of children in the control group, the cryotherapy group and the foot reflexology group respectively experienced tachycardia. The differences were not statistically significant.

During arterial puncture, it is clear from the same table that the percentages of the critically ill children who had tachycardia increased to 93.3%, 83.3% and 66.7% in the control group, the cryotherapy group and the foot reflexology group respectively. Statistical significant difference was found between control and foot reflexology groups, where P2=0.010.

Concerning heart rate immediately after the arterial puncture, it was revealed that the percentages of critically ill children who experienced tachycardia in the control group were declined to 80.0% compared to 66.7% in the cryotherapy and foot reflexology groups. The differences were not statistically significant.

Table 3 clarifies the effect of cryotherapy and foot reflexology on respiratory rate during arterial puncture among critically ill children. Before arterial puncture, it was observed that 76.7%, 83.3% and 80.0% of children in the control group, the cryotherapy group and the foot reflexology group had tachypnea respectively. Additionally, it was amazing that all critically ill children (100%) among the three groups of current study experienced tachypnea during arterial puncture.

Respiratory rate immediately after the arterial puncture exhibited that the percentages of the critically ill children who experienced tachypnea showed slight decline to 93.3% among children in the control group. On the other hand, 83.3% of those children experienced tachypnea immediately after the puncture in the cryotherapy and foot reflexology groups. No statistical significant differences were evident between the three groups of the study regarding respiratory rate neither during nor immediately after the arterial puncture.

Table 4 represents the effect of cryotherapy and foot reflexology on oxygen saturation during arterial puncture among critically ill children. Before arterial puncture, it can be seen from the table that children who had 95% or more oxygen saturation in the control group, the cryotherapy group and the foot reflexology group were 93.3%, 90.0% and 83.3% respectively.

During arterial puncture, it was observed that the percentages of the children who had 95% or more oxygen saturation declined nearly to two thirds of children (56.7%, 60.0% and 66.7%) in the control group, the cryotherapy group and the foot reflexology group respectively. There were no statistical significant differences.

Immediately after the arterial puncture, the same table showed that the percentages of children who had normal oxygen saturation raised to76.7%, 80.0% and 80.0% of children in the control group, the cryotherapy group and the foot reflexology group respectively. The differences were not statistically significant.

Table 5 explains the effect of cryotherapy and foot reflexology on alertness of critically ill children during arterial puncture. Before arterial puncture, the table clarified that all critically ill children in the three groups (100% each) were awake and alert.

During the puncture, the same table revealed that all critically ill children (100%) in the control group were in awake and hyperalert condition. Additionally, the same condition was also recognized among the vast majority of those in the cryotherapy and foot reflexology groups (90.0 % and 96.7 % respectively).

Immediately after puncture, it was amazing that awake and alert condition was found among 70.0% of critically ill children in the control and cryotherapy groups and among majority of those (83.3%) in the foot reflexology group. The differences were not statistically significant.

Table 6 shows the effect of cryotherapy and foot reflexology on calmness–agitation among critically ill children during arterial puncture. It was obvious that 73.3%, 80.0% and 90.0% of critically ill children were calm before the puncture in the control, cryotherapy and foot reflexology groups respectively.

During the puncture, it can be seen that 86.7% of critically ill children were very anxious in the control group, while the same percentage of those in the foot reflexology group were anxious. Moreover, 60.0% of critically ill children in cryotherapy group were also anxious. Statistical significant differences were found between the three groups, where P1=0.000, P2=0,000 and P3=0.020.

Immediately after the puncture, the same table highlights that 16.7% and 23.3% of critically ill children were regained their calm condition in the cryotherapy and foot reflexology groups respectively compared to none of those in the control group. Furthermore, it was obvious that nearly three quarters of critically ill children (73.3% and 70.0%) were recognized in slightly anxious state in cryotherapy and foot reflexology groups respectively, while 66.7% of critically ill children in control group were experienced anxious state. Statistical significant differences were found between control and cryotherapy groups as well as between control and foot reflexology groups (P= 0.000 for each).

Table 7 illustrates the breathing pattern of critically ill children among control, cryotherapy and foot reflexology groups. It was found that 80.0% of critically ill children among control and foot reflexology groups had spontaneous breathing compared to83.3% of those children in the cryotherapy group.

Table 8 presents the effect of cryotherapy and reflexology on respiratory response among mechanically ventilated critically ill children during arterial puncture. It was illustrated that 83.3% of the critically ill children in the control group had spontaneous and ventilator respiration compared to those among the two experimental groups (cryotherapy and foot reflexology groups) who had no spontaneous respiration as well as spontaneous and ventilator respiration (40% each) for cryotherapy group and (50% each) for foot reflexology group. The differences were not statistically significant.

During puncture, it is clear from the table that 50.0% of the children in the control group experienced active breathing against ventilator or regular coughing and the other 50.0% were fighting against ventilator. While, 50.0% of the children in the foot reflexology group exhibited restlessness or resistance to ventilator and the other half of the children had active breathing against ventilator or regular coughing. On the other hand, the majority of the children (80.0%) in the cryotherapy group experienced restlessness or resistance to ventilator. Statistical significant differences were found between control and cryotherapy groups and between control and foot reflexology groups (P1= 0.019 and P2= 0.049 respectively).

Regarding immediately after puncture, spontaneous and ventilator respiration was noticed among 66.7% of the children in the control group, 80.0% among those in the cryotherapy group, while found among all of the critically ill children in the foot reflexology group. No statistical significant differences were found.

Table 9 portrays the effect of cryotherapy and foot reflexology on crying among breathing spontaneously critically ill children during arterial puncture. Before puncture, the table showed that all critically ill children among the three groups revealed quiet breathing and no crying sounds (100.0% for each).

During puncture, it was found that 56.0% and 83.3% of breathing spontaneously children in the cryotherapy and foot reflexology groups respectively were recognized in a whining state compared to 4.2% of those in the control group. On the contrary, more than three quarters of breathing spontaneously critically ill children (79.2%) were in the control group were crying compared to none of those in the cryotherapy group and only 16.6% of children in the foot reflexology group. Statistical significant differences were detected between the three groups of the study (P1=0.000, P2=0.000 and P3=0.000).

Immediately after puncture, it can be seen from the same table that whining was observed in 66.7% of breathing spontaneously children in the control group compared to 8.3% and none of those in the foot reflexology and cryotherapy groups respectively. Fortunately, it was obvious that quiet breathing and no crying sounds state was noticed among 72.0% of the children in the cryotherapy and more than half of the foot reflexology groups (54.3%) compared to none of those in the control group. The differences were statistically significant found between the control and cryotherapy groups as well as between the control and the foot reflexology groups (P1=0.000, P2=0.000 and P3=0.000).

Table 10 highlights the effect of cryotherapy and reflexology on physical movement among critically ill children during arterial puncture**.** Before puncture, the table clarified that occasional slight movements were noticed among 63.3%, 76.7% and 90.0% of critically ill children in the control group, the cryotherapy group and the foot reflexology group respectively.

During the puncture, more than three quarters of the critically ill children (80.0% and 76.7%) showed vigorous movements limited to extremities in the control group and the cryotherapy group respectively. In contrast, more than half of the critically ill children in foot reflexology group (53.3%) displayed frequent slight movements. Statistical significant differences were found between control and cryotherapy groups, between control and foot reflexology groups as well as between cryotherapy and foot reflexology groups in relation to during and immediately after arterial puncture (P1=0.000, P2=0.000 and P3=0.017 respectively).

Regarding immediately after the puncture, it was portrayed that 80.0% of the critically ill children in control group experienced frequent slight movements, while occasional slight movements were observed among 46.7% and 86.7% of the critically ill children in cryotherapy and foot reflexology groups respectively. Statistical significant differences were evident between the three groups (P1=0.000, P2=0.000 and P3=0.000).

The effect of cryotherapy and foot reflexology on muscle tone of critically ill children during arterial puncture was obvious in Table 11. Before puncture, it is clear that all critically ill children in the cryotherapy and foot reflexology groups (100% each) and the vast majority of those (96.7%) in the control group had normal muscle tone.

During puncture, it was observed that increased muscle tone and flexion of fingers and toes were found among 76.7%, 83.3% and 90.0% of the critically ill children in the control, cryotherapy and foot reflexology groups respectively with no statistical significant differences.

Immediately after puncture, the same table illustrated that the percentages of the critically ill children who experienced normal muscle tone were 63.3% in the control group and 73.3% in the cryotherapy group compared to 83.3% of those in the foot reflexology group. However, the differences were not statistically significant.

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The effect of cryotherapy and foot reflexology on facial tension of critically ill children during arterial puncture was illustrated in Table 12. Before puncture, it was noticed that all critically ill children in the three groups (100% for each) showed normal facial tone. During puncture, facial muscles contorted and grimacing were found among 73.3% of critically ill children in control group. While, tension evident in some facial muscles were detected among 56.7% and 70.0% of those in the cryotherapy and foot reflexology groups respectively.

Concerning immediately after the puncture, the same table clarified that 50% of the critically ill children in the control group exhibited tension evident in some facial muscles, while the other half (50%) showed tension evident throughout facial muscles. Amazingly, the cryotherapy and foot reflexology groups had normal facial tone among 73.3% and 80.0% of the critically ill children respectively. Statistical significant differences were found between control and cryotherapy groups and also between control and foot reflexology groups in relation to during and immediately after arterial puncture, where P=0.000 for each.

The total pain percent scores experienced by critically ill children in the control, cryotherapy and foot reflexology groups during arterial puncture are represented in Table 13. It was observed from the table that pain was not noticed before the arterial puncture among the critically ill children of the three groups of the study (100.0% each).

During arterial puncture, the same table portrayed that more than one fifth of children (23.3% and 26.7%) among the cryotherapy and foot reflexology groups respectively exhibited mild pain compared to none in the control group. Moreover, moderate pain was found among 73.3% of the critically ill children in the control and foot reflexology groups. Additionally, it was also found among 76.7% of those in the cryotherapy group. On the other hand, severe pain was noticed among 26.7% of the critically ill children in the control group compared to none of those in either the cryotherapy group or the foot reflexology group.

Immediately after the puncture, it was interesting that the percentages of the critically ill children in the cryotherapy and foot reflexology groups who experienced no pain were 70.0% and 83.3% respectively. Furthermore, mild pain was observed among 83.3%, 30.0%, and 16.7% of the critically ill children in the control, cryotherapy and foot reflexology groups respectively. On the contrary, moderate pain was noticed among only 16.7% of the critically ill children in the control group compared to none of those in the cryotherapy and foot reflexology groups.

Statistical significant differences were found between the control and cryotherapy groups (P1= 0.000) and between the control and foot reflexology groups either during or immediately after the arterial puncture (P2= 0.000). While, there was no statistical significant difference between cryotherapy and foot reflexology groups neither during nor immediately after the puncture.

The table also illustrated that the critically ill children's mean percent scores were 12.76±3.55, 13.37±0.77 and 13.30±0.651 among the control, cryotherapy and foot reflexology groups respectively before arterial puncture. During the puncture, their mean percent scores increased to 26.50±1.50 among the control group compared to 22.33±1.22 and 22.20±1.18 among the cryotherapy and foot reflexology groups respectively. While, immediately after arterial puncture, the critically ill children's mean percent scores declined to19.63±1.75 among the control group in comparison with 15.50±2.34 in the cryotherapy group and 15.13±1.67 among the foot reflexology group.

4. DISCUSSION

Critically ill children are usually exposed to a numerous invasive and painful procedures in PICU. Procedural pain associated with arterial puncture in particular is one of most distressing and painful experiences for children (Bahorski et al., 2015). Additionally, pain assessment and measurement are the backbones of pain management (Kahsay, 2017). The current study findings clarified that all critically ill children in the three groups expressed their pain during arterial puncture through many physiological and behavioral changes. Moreover, the critically ill children among both study groups exhibited lower heart rate compared to those in control group with no statistical significant difference except between control and foot reflexology groups during the puncture. These findings could be justified by that touch in foot reflexology stimulates pressure receptors on foot which in turn stimulate the vagal nerve and increase vagal activity. This leads to slow heart rate. These findings are consistent with findings of Khalil (2017) and Abd El-Gawad and Elsayed (2015), that portrayed that the heart rates were differed significantly among foot reflexology group. Moreover, Shehata and Shehata (2017) and Haynes (2015) findings showed no a statistically significant differences between ice pack group and control group neither during nor immediately after the arterial puncture.

Regarding to the respiratory rate, the current study findings showed that all critically ill children among the three groups experienced tachypnea during arterial puncture with slight decline was noticed among the three groups of the study immediately after the puncture. These findings could be explained in the light of fact that more than three quarters of those children had tachypnea before the puncture. Furthermore, acute pain increase secretions of chemical substances such as stress hormones that results in hemodynamics instability and increase respiratory demands that reflected in to sort of tachypnea. These findings are matched with findings of Shehata and Shehata (2017) and Bastami, Azadi, and Maye (2015) that showed no statistically significant differences between ice pack and control groups neither during nor immediately after the puncture. On the other hand, Ghazavi, Pouraboli, Sabzevari, and Mirzaei (2016) and Koc and G¨ozen (2015) who reported that patients who received foot reflexology had more stabilized vital signs.

The results of the present study also highlighted that oxygen saturation of the critically ill children decreased during and immediately after puncture with no statistical significant differences among the three groups. This could be due to changes in respiratory pattern appearing in the form of breath holding or apnea. Moreover, increased intra-thoracic pressure associating vigorous crying in response to pain may cause oxygen desaturation. Additionally, foot reflexology has a strong evidence of restoring body hemodynamic stability. These results are in line with results of Abd El-Gawad and Elsayed (2015) among children who received cryotherapy and results of Darwish, Basiouny, and Ahmed (2015) among children who received foot reflexology intervention. While, these results are disagreed with Ghazavi et al. (2016) and Kara and Günes (2016) findings among foot reflexology group and Alalo et al. (2016) among cryotherapy group who reported that oxygen saturation constituted in the normal range.

Physiological indicators cannot be used alone to determine severity of pain among critically ill children. Thus, these responses are commonly observed simultaneously with child's behavioral responses for pain assessment such as facial tension, body movement and crying. Facial activity has been considered as the most reliable and consistent indicator of pain assessment for critically ill children. The findings of the present study highlighted that there was a statistical significant difference among the three groups of study regarding facial tension of children. Where, children in foot reflexology and cryotherapy groups showed less facial tension than those in the control group either during or immediately after the puncture. This could be related to that facial expression is a general non-verbal response to pain experienced by any person even children.

As a matter of fact, responses of children to pain are usually exhibited through form of increased motor activities such as physical movement, calmness/ agitation as well as muscle tone. The flexion withdrawal reflex is a clear, distinct withdrawal of the limb that can be evoked by a noxious stimulus. Additionally, young children have lower thresholds, more exaggerated, and longer-lasting reflex muscle contractions in responses to pain (Omar, Patel, Greydanus, & Merrick, 2016). Those facts are in harmony with the current study findings that showed that foot reflexology and cryotherapy decreased physical movement and improved calmness state of children during and immediately after the puncture with evident statistical significant differences among the three groups. Meanwhile, both non-pharmacological pain management modalities (cryotherapy and foot reflexology) decreased muscle tone during and immediately after puncture compared to the control group with no statistical significant differences. This could be interpreted in fact of fight or flight response evoked by adrenaline that released during painful stimuli as a protective response that involve extreme physical efforts or movements (Omar et al., 2016). In this study findings, more than half of those children were from three to less than four years old who expressed their pain through motor activity. Moreover, applying the foot reflexology technique and cryotherapy improve the blood and energy circulation, give sense of relaxation, and maintain the homoeostasis (Khaledifar, Nasiri, Khaledifar, Khaledifar, & Mokhtari, 2017). Similar findings reported by Darwish et al. (2015) among children who received foot reflexology and El-said et al. (2017) among children who received cryotherapy on puncture sites of arteriovenous fistula.

Observation of children's behavioral states, such as alertness, has been identified in children following painful procedures. The findings of this study illustrated that the vast majority of critically ill children exhibited awake and hyperalert state during the arterial puncture with no statistical significant differences between the three groups. Amazingly, the alertness states of those children were improved immediately after the puncture among three groups with no statistical significant differences detected among three groups. These findings can be related to the impact of foot reflexology and cryotherapy interventions on autonomic system, where it was reported a significant decrease in cortisol level from the baseline and increases active neurotransmitters such as serotonin and dopamine. Consequently, they provide a relaxed and better arousal state for critically ill children (Khaledifar et al., 2017). Findings of Farhadi and Esmailzadeh (2011) and Mansy,

Zaher, Waziry, and Eshak (2010) are congruent with these findings where they reported that children who received cryotherapy during penicillin injection showed less behavioral distress, more quiet state and less motor activity. Further, Kara and Günes (2016), Zarchi, Hosseini, Khankeh, Roghani, and Biglarian (2016) and Koc and G¨ozen (2015) findings also supported the study results regarding the effect of foot reflexology on children's behavioral state.

In fact, crying is a common behavioral response to pain in children. The critically ill children expressed their pain through different forms of crying that varied between moaning to screaming among breathing spontaneously children. As illustrated in the present study findings, a statistical significant effect of cryotherapy and foot reflexology were highlighted on crying of children during and immediately after the puncture compared to control group. Moreover, respiratory response is an alternative pain indicator for pain that is used among intubated critically ill children. In addition, both interventions were also having statistical significant effect on respiratory response of children during the puncture compared to the control group. These findings could be attributed to the fact that both interventions had analgesic effect with delayed nerve conduction velocity and increase pain tolerance (Pishkarmofrad Z, Navidian A, Ahmadabadi Ch, & Aliahmadi E, 2016). However, cryotherapy was more effective on crying and respiratory response than foot reflexology during and immediately after the arterial puncture. These findings could be justified by the virtue of cooling nature and analgesic effect of ice that divert the child's attention away from the puncture procedure itself. So they didn't experience any crying. These findings are supported by findings of Attia and Hassan (2017) and Youssif, Gaafer, and Abd-Elrazik (2013) who studied the effect of cryotherapy on children responses following arteriovenous fistula puncturing. These findings also agreed with findings of Yaghoubinia et al. (2016) who stated that reflexology as practical, affordable, and simple method is recommended to decrease the pain and increase the patient comfort.

Findings of this study clarified that the critically ill children in the control group and both studied groups experienced pain during and immediately after arterial puncturing procedure. This could be attributed to the process of arterial blood sampling procedure. It requires a deeper needle insertion and frequent needle redirection due to the invisibility nature of arteries. In addition, penetrating higher innervated arteries is worsened on repeated attempts that may be performed to obtain successful arterial blood sample. These findings are congruent with findings of Farahmand et al. (2017), Patout et al. (2015) and Wade, Crawfurd, Wade, and Holland (2015) who stated that the greater pain was associated with arterial punctures in children.

Arterial blood sampling is a painful procedure. As a result, inadequate pain management is linked to numerous immediate, harmful and life-threatening effects may ensue. So, many non-pharmacological measures have been put forward for reducing procedural pain. These include cryotherapy and foot reflexology technique (Wilson-Smith, 2011). Findings of the current study showed that cryotherapy significantly reduced puncture-related pain during and immediately after the puncture compared with a control group. These findings could be explained in light of the fact that cryotherapy lowers the temperature over the painful area of the skin to reduce the velocity of nerve conduction in C- and A- delta fibers, thereby slowing the transmission of pain signals. Furthermore, after tissue damage, vasoactive agents such as histamine are released that causes inflammation and leakage of fluid from blood vessels. Cryotherapy reduces inflammation through contraction of blood vessels and decreasing vasoactive agents of the damaged tissue (Alsantali, 2018). These results are congruent with results of Haynes (2015) and Shehata and Shehata (2017) who recommended that ice application is effective in reducing pain perception at arterial puncture site. Other study done by Attia and Hassan (2017) and found that the cryotherapy significantly reduced the sensation of pain at puncture site of arteriovenous fistula among children undergoing hemodialysis.

Foot reflexology is another effective non-pharmacological measure that can be applied to relieve pain as the use of massage technique during reflexology calls up the body's natural pain killers (Ghazal, 2014). In addition, by using pressure on reflexive points of sole that is in accordance with each part of the body, the balance returns to all over the body and improves comfort. This outcome helps in reducing pain and improving the sense of well-being (Zarchi et al., 2016). In line with this explanation, current study findings reflected that critically ill children in the foot reflexology group exhibited a significant reduction in pain severity during and immediately after the puncture. Moreover, Foot reflexology significantly reduced puncture-related pain in comparison with a control group with statistical significant differences was evident either during or immediately after the puncture. Findings of Özdemir et al. (2013) and Koc and G¨ozen (2015) are matched with the current study findings. Moreover, Babajani S, Babatabar H, Ebadi A, Mahmoudi H, and A (2014) added that Foot reflexology massage is a useful nursing intervention in removal of chest tube. Similarly, Darwish et al. (2015) Zarchi et al. (2016) and Öztürka, Sevila, Sarginb, and Yücebilginc (2018) mentioned that foot massage is an effective modality in the reduction of postoperative pain.

Although critically ill children of both studied groups experienced less pain throughout the puncture procedure than the control group. The findings of the current study highlighted that critically ill children in the foot reflexology group had less pain compared to critically ill children in the cryotherapy group, but no statistical significant difference was detected. These findings may be related to the fact explained in the Gate-control theory. This theory denoted that the large fibers of the skin are stimulated through massage either by rubbing or stroking through foot reflexology session, thus preventing the small fibers from transporting pain signals (Kara & Günes, 2016). Besides, these effects can be related to the general and long term behavioral effect of foot reflexology all over the body which induce a better relaxation and more attentive state (Khaledifar et al., 2017). Furthermore, the pressure applied during reflexology is meant to facilitate a physiological response and secretions of natural pain killers (Jones, Thomson, Irvine, & Leslie, 2013; Kaur et al., 2012).

According to extensive literature review, the current study is considered the first conducted one to assess the effect of foot reflexology versus cryotherapy on pain associated with arterial puncture among critically ill children. While, Yilmaz and Kiyak (2017) investigated the effect of local cold application on fibromyalgia pain and the results found that pain significantly decreased among cryotherapy group. Moreover, Bastani, Hajizadeh, Sa`atchi, and Haghani (2016) studied the effect of cryotherapy on pain associated with chest tube removal. So, the findings revealed pain intensity immediately after removal of chest tube was significantly reduced. Additionally, Babajani S et al. (2014) reported that foot reflexology massage is a useful nursing intervention in chest tube removal.

5. CONCLUSION

According to findings of the present study, it can be concluded that foot reflexology and cryotherapy were effective in reducing critically ill children's pain during and immediately after arterial puncturing procedure. Furthermore, critically ill children who received foot reflexology experienced less pain than those who received cryotherapy.

6. RECOMMENDATIONS

- Non-pharmacological pain relieving measures for critically ill children particularly foot reflexology and cryotherapy interventions should be incorporated in PICUs policies.
- Educational programs and /or workshops about non-pharmacological measures required to minimize critically ill children's pain should be carried out periodically for PICUs professionals to enhance their pain management skills.
- Booklets about methods of applying foot reflexology and cryotherapy interventions should be available for health personnel in PICUs.
- Pediatric critical care nurses should be encouraged to apply foot reflexology and cryotherapy interventions to reduce critically ill children's pain associating with arterial puncturing procedure.

Table1: Characteristics of Critically Ill Children.

Critically Ill Children's Characteristics	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)	
	No.	%	No.	%	No.	%
Age/ years						
• 3-	17	56.7	20	66.7	16	53.3
• 4-	7	23.3	5	16.7	8	26.7
• 5-6	6	20.0	5	16.7	6	20.0
Min –Max	3-6		3-6		3-6	
Mean ± S.D	3.63 ±.809		3.50 ± .777		3.67 ± .802	
Gender						
• Male	18	60.0	15	50.0	16	53.3
• Female	12	40.0	15	50.0	14	46.7
Diagnosis*						
• Bronchial Pneumonia	19	63.4	20	66.6	18	60.0
• Diabetic Keto-Acidosis	5	16.6	6	20.0	5	16.7
• Respiratory Distress	6	20.0	5	16.7	5	16.7
• Sepsis	3	10.0	3	10.0	4	13.3
• Cerebral Palsy	3	10.0	2	6.7	3	10.0

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Site of arterial puncture						
• Radial artery	5	16.7	2	6.7	6	20.0
• Brachial artery	0	0.0	0	0.0	0	0.0
• Femoral artery	25	83.3	28	93.3	24	80.0
Number of trials						
• First	20	66.7	19	63.3	21	70.0
• Second	6	20.0	9	30.0	8	26.7
• Third	4	13.3	2	6.7	1	3.3

- * : Categories are mutually exclusive.

Table 2: Effect of Cryotherapy and Foot Reflexology on Heart Rate during Arterial Puncture among Critically Ill Children.

Heart Rate (b/m)	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• Normal	12	40.0	13	43.3	14	46.7	χ^2=0.069	χ^2= 0.271	χ^2=0.067
• Tachycardia	18	60.0	17	56.7	16	53.3	P_1=0.793	P_2=0.602	P_3=0.795
Mean ± SD	129.93 ± 18.52		125.33±15.14		124.90±13.715				
During Puncture									
• Normal	2	6.7	5	16.7	10	33.3	χ^2= 1.456	χ^2= 6.667	χ^2=2.222
• Tachycardia	28	93.3	25	83.3	20	66.7	P_1=0.228	P_2=0.010*	P_3=0.136
Mean ± SD	142.13±18.60		133.43±14.54		134.43±14.424				
Immediately After Puncture									
• Normal	6	20.0	10	33.3	10	33.3	χ^2=1.364	χ^2= 1.363	----------
• Tachycardia	24	80.0	20	66.7	20	66.7	P_1=0.243	P_2=0.243	
Mean ± SD	136.37±17.94		128.93±14.56		130.40±12.692				

- **$\square^2$: Chi-Square Test □□□□□□□□□□ * Significant at P ≤0.05 Normal heart rate: 80-120 beats/minute.**
- **P_1**: test of significance between control and cryotherapy groups.
- **P_2**: test of significance between control and foot reflexology groups.
- **P_3**: test of significance between cryotherapy and foot reflexology groups.

Table 3: Effect of Cryotherapy and Foot Reflexology on Respiratory Rate during Arterial Puncture among Critically Ill Children.

Respiratory Rate (c/m)	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• Normal	7	23.3	5	16.7	6	20.0	χ^2= 0.417	χ^2=0.098	χ^2= 0.111
• Tachypnea	23	76.7	25	83.3	24	80.0	P_1=0.519	P_2=0.754	P_3=0.739
Mean ± SD	34.30 ±6.92		32.80±4.39		35.47±5.507				
During Puncture									
• Normal	0	0.0	0	0.0	0	0.0	-------	-------	-------
• Tachypnea	30	100.0	30	100.0	30	100.0			
Mean ± SD	42.77±7.96		38.70±4.92		42.17±5.36				
Immediately After Puncture									
• Normal	2	6.7	5	16.7	5	16.7	χ^2=1.456	χ^2=1.456	----------
• Tachypnea	28	93.3	25	83.3	25	83.3	P_1=0.228	P_2=0.228	
Mean ± SD	38.33± 7.46		34.83±5.233		36.73±6.863				

- **Normal respiratory rate: 20-28 cycles/minute.**

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Table 4: Effect of Cryotherapy and Foot Reflexology on Oxygen Saturation during Arterial Puncture among Critically Ill Children.

O_2 Saturation (%)	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• >95	28	93.3	27	90.0	25	83.3	χ^2=0.218	χ^2=1.456	χ^2=0.577
• < 95	2	6.7	3	10.0	5	16.7	P_1=0.640	P_2=0.228	P_3=0.448
Mean ± SD	98.00 ±1.85		97.43±2.11		96.67±2.670				
During Puncture									
• >95	17	56.7	18	60.0	20	66.7	χ^2=0.069	χ^2=0.635	χ^2=0.287
• < 95	13	43.3	12	40.0	10	33.3	P_1=0.793	P_2=0.426	P_3=0.592
Mean ± SD	94.60 ±3.26		95.57±3.26		94.73±3.571				
Immediately after Puncture									
• >95	23	76.7	24	80.0	24	80.0	χ^2=0.098	χ^2=0.098	----------
• < 95	7	23.3	6	20.0	6	20.0	P_1=0.754	P_2=0.754	
Mean ± SD	95.77± 3.24		96.87±2.33		95.90±2.833				

- **Normal oxygen saturation: 95-99%.**

Table 5: Effect of Cryotherapy and Foot Reflexology on Alertness of Critically Ill Children during Arterial Puncture.

Alertness	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• Deeply asleep	0	0.0	0	0.0	0	0.0	-------	-------	-------
• Lightly asleep	0	0.0	0	0.0	0	0.0			
• Drowsy	0	0.0	0	0.0	0	0.0			
• Awake and alert	30	100.0	30	100.0	30	100.0			
• Awake and hyperalert	0	0.0	0	0.0	0	0.0			
During Puncture									
• Deeply asleep	0	0.0	0	0.0	0	0.0			
• Lightly asleep	0	0.0	0	0.0	0	0.0	χ^2=3.158	χ^2=1.017	χ^2=1.071
• Drowsy	0	0.0	0	0.0	0	0.0	P_1=0.076	P_2=0.313	P_3=0.301
• Awake and alert	0	0.0	3	10.0	1	3.3			
• Awake and hyperalert	30	100.0	27	90.0	29	96.7			
Immediately After Puncture									
• Deeply asleep	0	0.0	0	0.0	0	0.0			
• Lightly asleep	0	0.0	0	0.0	0	0.0	-------	χ^2=1.071	χ^2=1.491
• Drowsy	0	0.0	0	0.0	0	0.0		P2=0.222	P3=0.222
• Awake and alert	21	70.0	21	70.0	25	83.3			
• Awake and hyperalert	9	30.0	9	30.0	5	16.7			

Table 6: Effect of Cryotherapy and Foot Reflexology on Calmness–Agitation among Critically Ill Children during Arterial Puncture.

Calmness–Agitation	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• Calm	22	73.3	24	80.0	27	90.0			
• Slightly anxious	8	26.7	6	20.0	3	10.0	χ^2=0.373	χ^2=2.783	χ^2=1.176
• Anxious	0	0.0	0	0.0	0	0.0	P_1=0.542	P_2=0.095	P_3=0.278
• Very anxious	0	0.0	0	0.0	0	0.0			
• Panicky	0	0.0	0	0.0	0	0.0			
During Puncture									
• Calm	0	0.0	0	0.0	0	0.0			
• Slightly anxious	0	0.0	0	0.0	0	0.0	χ^2=27.158	χ^2=46.133	χ^2=5.455
• Anxious	0	0.0	18	60.0	26	86.7	P_1=0.000*	P_2=0.000*	P_3=0.020*
• Very anxious	26	86.7	12	40.0	4	13.3			
• Panicky	4	13.3	0	0.0	0	0.0			
Immediately After Puncture									
• Calm	0	0.0	5	16.7	7	23.3			
• Slightly anxious	9	30.0	22	73.3	21	70.0	χ^2=36.072	χ^2=26.489	χ^2=3.037
• Anxious	20	66.7	3	10.0	2	6.7	P_1=0.000*	P_2=0.000*	P_3=0.757
• Very anxious	1	3.3	0	0.0	0	0.0			
• Panicky	0	0.0	0	0.0	0	0.0			

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Table 7: Breathing Pattern of Critically Ill Children among Control, Cryotherapy and Foot Reflexology Groups.

Breathing Pattern of Critically Ill Children	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)	
	No	%	No	%	No	%
• Mechanically ventilated	6	20.0	5	6.7	6	20.0
• Breathing spontaneously	24	80.0	25	83.3	24	80.0

Table 8: Effect of Cryotherapy and Foot Reflexology on Respiratory Response among Mechanically Ventilated Critically Ill Children during Arterial Puncture.

Respiratory Response #	Control Group (n=6)		Cryotherapy Group (n=5)		Foot Reflexology Group (n=6)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• No spontaneous respiration	1	16.7	2	40.0	3	50.0			
• Spontaneous and ventilator respiration	5	83.3	2	40.0	3	50.0	χ^2=2.549	χ^2=1.500	χ^2=1.320
• Restlessness or resistance to ventilator	0	0.0	1	20.0	0	0.0	P_1=0.280	P_2=0.221	P_3=0.517
• Active breathing against ventilator or regular coughing	0	0.0	0	0.0	0	0.0			
• Fighting against ventilator	0	0.0	0	0.0	0	0.0			
During Puncture									
• No spontaneous respiration	0	0.0	0	0.0	0	0.0			
• Spontaneous and ventilator respiration	0	0.0	0	0.0	0	0.0	χ^2=7.975	χ^2=6.000	χ^2=1.061
• Restlessness or resistance to ventilator	0	0.0	4	80.0	3	50.0	P_1=0.019*	P_2=0.049*	P_3=0.303
• Active breathing against ventilator or regular coughing	3	50.0	1	20.0	3	50.0			
• Fighting against ventilator	3	50.0	0	0.0	0	0.0			
Immediately After Puncture									
• No spontaneous respiration	0	0.0	1	20.0	0	0.0			
• Spontaneous and ventilator respiration	4	66.7	4	80.0	6	100.0	χ^2=2.933	χ^2=2.400	χ^2=1.320
• Restlessness or resistance to ventilator	2	33.3	0	0.0	0	0.0	P_1=0.231	P_2=0.121	P_3=0.250
• Active breathing against ventilator or regular coughing	0	0.0	0	0.0	0	0.0			
• Fighting against ventilator	0	0.0	0	0.0	0	0.0			

- **#: Numbers of mechanically ventilated children.**

Table 9: Effect of Cryotherapy and Foot Reflexology on Crying among Breathing Spontaneously Critically Ill Children during Arterial Puncture.

Crying*	Control Group (n=24)		Cryotherapy Group (n=25)		Foot Reflexology Group (n=24)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• Quiet breathing, no crying sounds	24	100.0	25	100.0	24	100.0			
• Occasional sobbing or moaning	0	0.0	0	0.0	0	0.0			
• Whining (monotone)	0	0.0	0	0.0	0	0.0	-------	-------	-------
• Crying	0	0.0	0	0.0	0	0.0			
• Screaming or shrieking	0	0.0	0	0.0	0	0.0			
During Puncture									
• Quiet breathing, no crying sounds	0	0.0	0	0.0	0	0.0			
• Occasional sobbing or moaning	0	0.0	11	44.0	0	0.0			
• Whining (monotone)	1	4.2	14	56.0	20	83.3	$^{MC}P_1$=0.000*	$^{MC}P_2$=0.000*	$^{MC}P_3$=0.000*
• Crying	19	79.2	0	0.0	4	16.7			
• Screaming or shrieking	4	16.6	0	0.0	0	0.0			
Immediately After Puncture									
• Quiet breathing, no crying sounds	0	0.0	18	72.0	13	54.2			
• Occasional sobbing or moaning	6	25.0	7	28.0	9	37.5			
• Whining (monotone)	16	66.7	0	0.0	2	8.3	$^{MC}P_1$=0.000*	$^{MC}P_2$=0.000*	$^{MC}P_3$=0.244
• Crying	2	8.3	0	0.0	0	0.0			
• Screaming or shrieking	0	0.0	0	0.0	0	0.0			

- **^{MC}P: Monte Carlo Test.**
- *: Numbers of breathing spontaneously children only.

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Table 10: Effect of Cryotherapy and Foot Reflexology on Physical Movement among Critically Ill Children during Arterial Puncture.

Physical Movement	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• No movement	2	6.7	3	10.0	0	0.0	$^{MC}P_1$=0.284	$^{MC}P_2$=0.039*	$^{MC}P_3$=0.246
• Occasional (3 or fewer) slight movements	19	63.3	23	76.7	27	90.0			
• Frequent (more than 3) slight movements	9	30.0	4	13.3	3	10.0			
• Vigorous movements limited to extremities	0	0.0	0	0.0	0	0.0			
• Vigorous movements including torso and head	0	0.0	0	0.0	0	0.0			
During Puncture									
• No movement	0	0.0	0	0.0	0	0.0	$^{MC}P_1$=0.000*	$^{MC}P_2$=0.000*	χ^2=5.711 P_3=0.017*
• Occasional (3 or fewer) slight movements	0	0.0	0	0.0	0	0.0			
• Frequent (more than 3) slight movements	0	0.0	7	23.3	16	53.3			
• Vigorous movements limited to extremities	24	80.0	23	76.7	14	46.7			
• Vigorous movements including torso and head	6	20.0	0	0.0	0	0.0			
Immediately After Puncture									
• No movement	0	0	4	13.3	0	0.0	$^{MC}P_1$=0.000*	$^{MC}P_2$=0.000*	$^{MC}P_3$=0.000*
• Occasional (3 or fewer) slight movements	3	10.0	14	46.7	26	86.7			
• Frequent (more than 3) slight movements	24	80.0	12	40.0	4	13.3			
• Vigorous movements limited to extremities	3	10.0	0	0.0	0	0.0			
• Vigorous movements including torso and head	0	0	0	0.0	0	0.0			

Table 11: Effect of Cryotherapy and Foot Reflexology on Muscle Tone of Critically Ill Children during Arterial Puncture.

Muscle Tone	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P_1	P_2	P_3
Before Puncture									
• Muscles totally relaxed, no muscle tone	0	0.0	0	0.0	0	0.0	χ^2=1.017 P_1=0.313	χ^2=1.017 P_2=0.313	------
• Reduced muscle tone, less resistance than normal	0	0.0	0	0.0	0	0.0			
• Normal muscle tone	29	96.7	30	100.0	30	100.0			
• Increased muscle tone and flexion of fingers and toes	1	3.3	0	0.0	0	0.0			
• Extreme muscle rigidity and flexion of fingers and toes	0	0.0	0	0.0	0	0.0			
During Puncture									
• Muscles totally relaxed, no muscle tone	0	0.0	0	0.0	0	0.0	χ^2=0.417 P_1=0.519	χ^2=1.920 P_2=0.166	χ^2=0.577 P_3=0.488
• Reduced muscle tone, less resistance than normal	0	0.0	0	0.0	0	0.0			
• Normal muscle tone	0	0.0	0	0.0	0	0.0			
• Increased muscle tone and flexion of fingers and toes	23	76.7	25	83.3	27	90.0			
• Extreme muscle rigidity and flexion of fingers and toes	7	23.3	5	16.7	3	10.0			
Immediately After Puncture									
• Muscles totally relaxed, no muscle tone	0	0.0	0	0.0	0	0.0	χ^2=0.693 P_1=0.405	χ^2=3.068 P_2=0.080	χ^2=0.884 P_3=0.347
• Reduced muscle tone, less resistance than normal	0	0.0	0	0.0	0	0.0			
• Normal muscle tone	19	63.3	22	73.3	25	83.3			
• Increased muscle tone and flexion of fingers and toes	11	36.7	8	26.7	5	16.7			
• Extreme muscle rigidity and flexion of fingers and toes	0	0.0	0	0.0	0	0.0			

Table 12: Effect of Cryotherapy and Foot Reflexology on Facial Tension of Critically Ill Children during Arterial Puncture.

Facial Tension	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P1	P2	P3
Before Puncture									
• Facial muscles totally relaxed	0	0.0	0	0.0	0	0.0	-------	-------	-------
• Normal facial tone	30	100.0	30	100.0	30	100.0			
• Tension evident in some facial muscles	0	0.0	0	0.0	0	0.0			
• Tension evident throughout facial muscles	0	0.0	0	0.0	0	0.0			
• Facial muscles contorted and grimacing	0	0.0	0	0.0	0	0.0			
During Puncture									
• Facial muscles totally relaxed	0	0.0	0	0.0	0	0.0	χ^2=40.190 P_1=0.000*	χ^2=43.059 P_2=0.000*	χ^2=1.148 P_3=0.284
• Normal facial tone	0	0.0	0	0.0	0	0.0			
• Tension evident in some facial muscles	0	0.0	17	56.7	21	70.0			
• Tension evident throughout facial muscles	8	26.7	13	43.3	9	30.0			
• Facial muscles contorted and grimacing	22	73.3	0	0.0	0	0.0			
Immediately After Puncture									
• Facial muscles totally relaxed	0	0.0	0	0.0	0	0.0	χ^2=35.000 P_1=0.000*	χ^2=42.857 P_2=0.000*	$^{MC}P_3$=0.316
• Normal facial tone	0	0.0	22	73.3	24	80.0			
• Tension evident in some facial muscles	15	50.0	5	16.7	6	20.0			
• Tension evident throughout facial muscles	15	50.0	3	10.0	0	0.0			
• Facial muscles contorted and grimacing	0	0.0	0	0.0	0	0.0			

Table 13: The Total Pain Percent Scores Experienced by Critically Ill Children among the Control, Cryotherapy and Foot Reflexology Groups during Arterial Puncture.

Pain Assessment	Control Group (n=30)		Cryotherapy Group (n=30)		Foot Reflexology Group (n=30)		Test of Significance		
	No	%	No	%	No	%	P1	P2	P3
Before Puncture									
• No pain	30	100	30	100	30	100	----------	----------	----------
• Mild pain	0	0	0	0	0	0			
• Moderate pain	0	0	0	0	0	0			
• Severe pain	0	0	0	0	0	0			
• **Mean ± SD**	12.76±3.55		13.37±0.77		13.30±0.651				
During Puncture									
• No pain	0	0	0	0	0	0	$^{MC}P_1$=0.000*	$^{MC}P_2$=0.000*	χ^2=0.089 P_3=0.766
• Mild pain	0	0	7	23.3	8	26.7			
• Moderate pain	22	73.3	23	76.7	22	73.3			
• Severe pain	8	26.7	0	0.0	0	0			
• **Mean ± SD**	26.50±1.50		22.33±1.22		22.20±1.18				
Immediately After Puncture									
• No pain	0	0.0	21	70.0	25	83.3	$^{MC}P_1$=0.000*	$^{MC}P_2$=0.000*	χ^2=1.491 P_3=0.222
• Mild pain	25	83.3	9	30.0	5	16.7			
• Moderate pain	5	16.7	0	0	0	0			
• Severe pain	0	0.0	0	0	0	0			
• **Mean ± SD**	19.63±1.75		15.50±2.34		15.13±1.67				

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