Effectiveness of Nurses` Training Program in Prevention of Intravenous Infiltration and Extravasation among Children at Khartoum State Children's Hospitals – Sudan

A thesis submitted in fulfillment of the requirements for the degree of PhD

In paediatric nursing

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قال تعالى:

(وَقِلْ أَعْمَلُواْ فَسَيُبْرَءَنَّكُمْ وَرَسُولُنَا وَالْمُؤْمِنُونَ وَسَتَرْدُونَ)

(إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيَنْبُأُكُم بِمَا كُنْتُمْ تَعْمَلُونَ)

صدق الله العظيم

سورة التوبة 105
Dedication

To my mother and soul of my father...
To my sisters...
To children the future of Sudan...
Acknowledgment

I respect and thank the Al Neelain University, the graduate college for providing me an opportunity to do the thesis and giving me all support.
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Very special thanks to Dr. Hanadi Mohamed Elhassan and Dr. Ihsan Elyamni for helping and directing this research as required. I am grateful to Dr. Mohamed Gabraddar for his valuable criticism. I would like to acknowledge the help and cooperation of administrative authorities, matrons and Nurses in Ahmed Gasim Children's Hospital, Mohammed Elamin Hamid Children's Hospital, Gafar Ibn Auf Children's Referral Hospital, and ELbuluk Children's Hospital .Thanks also extended to Mariam Dahab ,Mai Asim , Tagwa Abdelbaset and Thuraia Osman for their support and encouragement to complete my study.
Abstract

Background and Objective: Infiltration and extravasation are complications of intravenous therapy involving unintended leakage of solution into the surrounding tissue. Consequences range from local irritation to amputation. Studies emphasize the need for regular education for nurses to tackle current deficiencies in knowledge and skills including evidence-based education. The study aimed to evaluate the effectiveness of the nurses’ training program in the prevention of intravenous infiltration and extravasation among children in Khartoum state hospitals.

Methodology: An Interventional hospital based study pre -post training for the same group, was conducted in four children's governmental hospitals in Khartoum state, Ahmed Gasim Children's Hospital, Mohammed Elamin Hamid Children's Hospital, Gafar Ibn Auf Children's Referral Hospital, and ELbuluk Children's Hospital. 165 participants were selected using a simple random sampling technique. Data was collected by a structured face to face interview questionnaire to assess nurses’ knowledge, and an observational checklist to assess nurses’ practice, based on Standards of Practice developed by the Infusion Nursing Society (INS). Reliability of the tools was tested by a pilot study. Pre and post intervention-training covering knowledge and practice was done. Data were analyzed by using the computer Statistical Package for Social Sciences (SPSS) version 20. Results: The study revealed that; only (1.8%) of the participants had good level of knowledge about definition of extravasation preprogram which improved to (78.8%) post program. (3.6%) of the participants had good level of knowledge that the insertion site must be visible preprogram, knowledge improved to (97.0%) post program, moreover the study showed that (20.0%) of the participants had poor practice, they flushing intravenous cannula with sterile water, which improved to (90.3%) post training. In addition to that 57.6% of the participants had poor practice, they dilute vesicant medications with less amounts than required, compared to (88.5%) post training. The overall results showed significant differences between levels of participants' knowledge and practice pre/post study (P value 0.001). Conclusion: The training program had a significant positive effect on the participants' knowledge and practice. It was concluded that training programs should be considered as a part of nurses' improvement. The study recommended that education, guideline, in-service training, and standards for intravenous therapy should be adopted in all paediatric hospitals to ensure the best practice in each hospital.
عملية الت чаще وآليات: التسريب الوريدي والانصباب الدمى من مضاعفات العلاج بالوردية حيث يتسرب المحلول حول الأنسجة المحيطة بالوريد. عاقبة ذلك التشريب تتراوح بين التحسس الموضعي إلى البتر. وتأتي الدراسات على الحاجة إلى التدريب المستمر للدورة على الأدلة للمرضى والممرضات لمعالجة القصور في المعرفة. يوجد ترتيب للدراسة المحيطة إلى تقييم تأثير برنامج تدريبي للمرضى فيما يتعلق بالإجراءات الوقائية للتسريب الوريدي والانصباب الدمى بين الأطفال بمستشفيات الاطفال. طرق البحث: دراسة تداخلية (قبل وبعد التدريب) أجريت في أربع مستشفيات اطفال في ولاية القاهرة. النتائج: تم اختبار 165 مشارك على طريق الوباء العدلي للبيئة بمعظم سنوات الخبرة. تم جمع البيانات باستخدام الاستبيان التفاعلي وغير المتفق لتبني معرفة ومشاركة الممرضين والممرضات للمريض المصاب بالانصباب الوريدي والانصباب الدمى. وقد تم استخدام الدراسات قبل برنامج التدريب في نسبة 20% من المشاركين في الدراسة. تبين النتائج أن 78.8% من المشاركين لديهم معرفة بأن موضع إدخال القسطرة الوريدية يجب أن يكون مرتبًا قبل البرامج التدريبية. خلاصة: أظهرت النتائج الدراسية أن 88.5% من المشاركين خفض درجة الأدوية المنفعة (الحارقة) بعد البرامج التدريبية. الإرشادات: الاعتماد على الأدلة والعمليات المصرفية للعلاج الوريدي والانصباب الدمى. الاستشارة والتعليم المستمر لصياح التدريب الفنى للعلاج الوريدي والانصباب الدمى. تراجع معرفة،ة من المواد المسببة التسريب الوريدي والانصباب الدمى بين الأطفال.
<table>
<thead>
<tr>
<th>Dedication</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgement</td>
<td>III</td>
</tr>
<tr>
<td>Abstract in English</td>
<td>IV</td>
</tr>
<tr>
<td>Abstract in Arabic</td>
<td>V</td>
</tr>
<tr>
<td>Table of contents</td>
<td>VI</td>
</tr>
<tr>
<td>List of tables</td>
<td>VII</td>
</tr>
<tr>
<td>List of figures</td>
<td>VIII</td>
</tr>
<tr>
<td>List of abbreviations</td>
<td>IX</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter One</td>
<td></td>
</tr>
<tr>
<td>Background</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the problem</td>
<td>2</td>
</tr>
<tr>
<td>Justification</td>
<td>2</td>
</tr>
<tr>
<td>Objectives</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter Two</td>
<td>4</td>
</tr>
<tr>
<td>Literature Review</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter three</td>
<td>25</td>
</tr>
<tr>
<td>Research Methodology</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter four</td>
<td>34</td>
</tr>
<tr>
<td>Results</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter five</td>
<td>57</td>
</tr>
<tr>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td>Conclusion and Recommendations</td>
<td>61</td>
</tr>
<tr>
<td>References</td>
<td>62</td>
</tr>
<tr>
<td>Table No</td>
<td>Name of Title</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.</td>
<td>The participants’ level of knowledge pre / post program about site selection.</td>
</tr>
<tr>
<td>2.</td>
<td>The participants’ level of knowledge pre / post program after insertion of cannula.</td>
</tr>
<tr>
<td>3.</td>
<td>The participants’ level of knowledge pre / post program about documentation of insertion cannula.</td>
</tr>
<tr>
<td>4.</td>
<td>The participants’ level of knowledge pre / post program about identification of intravenous infiltration.</td>
</tr>
<tr>
<td>5.</td>
<td>The participants’ awareness pre /post program about infiltration scale.</td>
</tr>
<tr>
<td>6.</td>
<td>The participants’ level of knowledge pre / post program about infiltration grading scale.</td>
</tr>
<tr>
<td>7.</td>
<td>The participants’ level of knowledge pre / post program about clinical signs of extravasation.</td>
</tr>
<tr>
<td>8.</td>
<td>The participants’ level of knowledge pre / post program about pharmacological factors risk for extravasation.</td>
</tr>
<tr>
<td>9.</td>
<td>The participants’ level of knowledge pre / post program about antibiotics associated with extravasation.</td>
</tr>
<tr>
<td>10.</td>
<td>The participants’ level of knowledge pre / post program about IVF and electrolytes solutions associated with extravasation</td>
</tr>
<tr>
<td>11.</td>
<td>The participants’ level of knowledge pre / post program about Vasocompressive agents associated with extravasation.</td>
</tr>
<tr>
<td>12.</td>
<td>The participants’ level of knowledge pre / post program about consequences of infiltration and extravasation.</td>
</tr>
<tr>
<td>13.</td>
<td>Total knowledge pre/post program by using Paired Samples t Test</td>
</tr>
<tr>
<td>14.</td>
<td>The participants’ level of practice pre / post program about preventive measures of IV infiltration and extravasation based on INS standard of practice.</td>
</tr>
<tr>
<td>15.</td>
<td>The participants’ level of practice pre / post program about early detection of IV infiltration and extravasation</td>
</tr>
<tr>
<td>16.</td>
<td>Total practice pre/post program by using Paired Samples t Test.</td>
</tr>
<tr>
<td>17.</td>
<td>The participants’ level of practice pre/post program about immediate intervention when IV infiltration or extravasation occurs.</td>
</tr>
</tbody>
</table>

**List of tables**
List of figures

<table>
<thead>
<tr>
<th>Figures No</th>
<th>Figures</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Gender of the participants.</td>
<td>33</td>
</tr>
<tr>
<td>II</td>
<td>Age of the participants.</td>
<td>34</td>
</tr>
<tr>
<td>III</td>
<td>Qualification of the participants.</td>
<td>35</td>
</tr>
<tr>
<td>IV</td>
<td>Experience of the participants.</td>
<td>36</td>
</tr>
<tr>
<td>V</td>
<td>Previous training in complication of intravenous therapy.</td>
<td>37</td>
</tr>
<tr>
<td>VI</td>
<td>The participants’ level of knowledge pre / post program about definition of intravenous infiltration.</td>
<td>41</td>
</tr>
<tr>
<td>VII</td>
<td>The participants’ level of knowledge pre / post program about definition of extravasation.</td>
<td>45</td>
</tr>
</tbody>
</table>

List of abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDC</td>
<td>Center for Disease Control and Prevention</td>
</tr>
<tr>
<td>EPIC</td>
<td>Evidence-Based <em>peripheral Intravenous Cannula</em></td>
</tr>
<tr>
<td>I.V</td>
<td>Intravenous</td>
</tr>
<tr>
<td>INS</td>
<td>Infusion Nurses Society</td>
</tr>
<tr>
<td>PH</td>
<td>Potential of Hydrogen</td>
</tr>
<tr>
<td>PIVC</td>
<td>Peripheral Intravenous Catheter</td>
</tr>
<tr>
<td>PIV</td>
<td>Peripheral Intravenous</td>
</tr>
<tr>
<td>USP</td>
<td>Unique Selling Proposition</td>
</tr>
<tr>
<td>VAD</td>
<td>Vascular Access Device</td>
</tr>
</tbody>
</table>
1. Introduction

1.1 Background

Peripheral intravenous access insertion is nearly universal procedure for medical management for paediatric patients in the hospital; it is a technically difficult and complicated procedure that needs to be performed successfully\(^{(1,2)}\).

Intravenous infusion therapy is associated with many complications including infiltration and extravasation. Nurses are expected to maintain competence in peripheral intravenous site care to enhance the best patient outcomes and prevent potentially life-threatening complications\(^{(3)}\).

Infiltration is the leakage of non-vesicant solution into the surrounding tissue and extravasation is inadvertent leakage of a vesicant solution into surrounding tissues. \(^{(4)}\)
Vesicant refers to any medication or fluid with the potential for causing blisters, severe tissue injury or necrosis \(^5\). Lack of the knowledge to these vesicants might increase the risk extravasation\(^6\).

Infiltration and extravasation can be caused by physiochemical factors, including PH and osmolarity of some drugs, mechanical factors, occurring either during the initial cannula insertion or while the cannula is in place \(^7\).

Children may be more susceptible to peripheral intravenous infiltration and extravasation because of developmental and physiological factors, such as communication skills, activity level, and fragile vein. Study by Sauerland mentioned that small children were liable to intravenous infiltration because they were likely to be more active and able to move more freely than infants \(^8, 9\).

The Infusion Nurses Society (INS) developed an infiltration scale that measured edema in inches and graded numerically from zero to four to assess severity of infiltration \(^10\). Nurses are required to observe intravenous site for pain, crying with or difficulty while flushing, redness, capillary refill, swelling, blanching, skin temperature, and pulse for early recognition of the infiltration \(^11\).

The nursing role is an application of proper techniques which can be used to avoid many cases of complications, such as selecting appropriate intravenous site, checking the catheter before, during, and after administration of vesicants, avoiding unnecessary coverage of the insertion site, to recognize the early signs and symptoms of infiltration and extravasation through systematic hourly intravenous site assessments, these various measures help to prevent or limit further damage to the vein and surrounding tissues. It is necessary that the nurses have the knowledge, skills and technical skills that are acquired through training programs and through educational actions \(^12, 13, 14\).

1.2 Statement of the Problem

Maintenance and care of peripheral intravenous access sites is an integral nursing responsibility to ensure venous access for medication and fluid administration \(^15\).

It is estimated that 78% of paediatric peripheral intravenous (PIV) lines become infiltrated and 11% of neonatal intensive care unit patients have IV extravasation. A study at Australia
found that a quarter (24.8%) of peripheral intravenous catheters inserted in the paediatric emergency department failed due to infiltration\(^{10, 16}\).

The most common complication associated with peripheral intravenous use in infants is infiltration and occurring in 23–78% of complications\(^{17}\).

The outcome from infiltration event can range from edema in an extremity to full-thickness skin loss, muscle or tendon necrosis, and in some cases, even amputation, these problems not only increased prolonged hospitalization and increased medical costs but also resulted in permanent damage and limitations of physical functions in paediatric patient\(^{18, 19, 20}\).

So considering these negative consequences of IV infiltration and extravasation, it is important for nurses to improve practice and knowledge through specific education and training. This provides high quality and effective health care for patients\(^{21}\). Therefore, this study aims to study the effectiveness of nurses’ training program in prevention of intravenous infiltration and extravasation among children.

### 1.3 Justification:

Studies by Hadaway claimed that nurses’ lack of standardization in practice and knowledge of peripheral intravenous cannula care directly affects patients’ safety and outcomes and mentioned that “to prevent infiltration, one has to follow the standard of the INS and the policies and procedures of your facility\(^{22, 23}\).” There is lack of published studies from Sudan regarding intravenous infiltration and extravasation among children.
1.4 Research Question

- Will a training program improve nurses’ knowledge and practice in prevention of intravenous infiltration and extravasation among children?

1.5 Objectives of the research

1.5.1 General objective

To study the effectiveness of nurses’ training program in prevention of intravenous infiltration and extravasation among children at Khartoum state hospitals –Sudan 2018

1.5.2 Specific objectives

1- To assess nurses’ knowledge about preventative measures of intravenous infiltration and extravasation pre & post intervention.

2- To identify nurses’ practice regarding prevention, detection and management of intravenous infiltration and extravasation pre & post intervention.

3- To evaluate the effect of the training program post the study.
2. Literature Review:

2.1 Introduction:

The terms infiltration and extravasation are often used interchangeably and involve IV fluid leakage into the tissue surrounding the insertion site. The difference between the 2 terms is determined by the type of IV fluid that infiltrates. Infiltration involves the leakage of an IV fluid without potential to cause tissue damage, whereas extravasation involves the leakage of a vesicant, or IV fluid that can potentially cause tissue damage\(^2\).\(^4\).

It is important to educate and train nurses associated with IV therapy with the necessary skills to anticipate problems and take actions to prevent occurring and ensure regular and comprehensive training programs kept up-to-date with theoretical and practical elements for safe and effective practice\(^25\).

Across-sectional study conducted for assessment to knowledge and practice on IV therapy. A systematic random sampling technique was used adopted 177 nurses. The study found that (15.3%) participated in in-service education and (46.8%) participated in in-service education had adequate knowledge on IV therapy. And 68% and nurses were not practicing appropriately regarding caring and maintaining peripheral intravenous cannula\(^26\).

2.2 Preventive measures of IV infiltration and extravasation

The need to focus on prevention is an important finding regarding infiltrations in the paediatric population\(^27\).

Prevention of infiltration and extravasation begin with choosing appropriate IV gauge, careful site selection, frequent visual assessment, patency of IV and recognize signs and symptoms of infiltration and extravasation\(^28\).

A lot of practitioners peripheral intravenous catheter knowledge and insertion skill deficits have been identified, including patient assessment, insertion site selection, catheter selection and insertion, catheter securement, dwell time, complication identification and treatment, and compliance with best practice guidelines and need for effective education strategies\(^29\).

It is necessary to establish preventive measures and maintenance in the paediatric wards in order to allow venous infusions safely and avoiding the complications related to peripheral cannulation such as infiltration and extravasation\(^12\).
Standards established by the INS require that a nurse who administers IV medication or fluid know the possible adverse effects and the interventions to undertake before starting the infusion. Before administering the infusion the nurse must assess the patency of the vein and the catheter. This is done by checking for lack of resistance when flushing the catheter, brisk blood return from the catheter, and a free-flowing gravity infusion. In addition, the nurse should palpate the area above the insertion site, assess the length of dwell time for the catheter (older catheters are more likely to be associated with complications), and compare the appearance of the two extremities\(^4\).

### 2.2.1 Cannulation

Intravenous infiltration occurs if cannula too large for diameter of vein, puncture of distal wall of vein during cannulation, poorly secured cannula e.g. too loose and mechanical friction from cannula causes vein puncture; taping that is too tight above the cannula tip can act as a tourniquet disrupting flow and rupturing the vessel wall, over-manipulation of the cannula and delivery of fluid at high rate or pressure. Peripheral intravenous catheters used for medication and continuous intravenous fluids can put pressure on the vein, which cause the vein to expand and infiltrate\(^3^0\).

#### 2.2.2 Selection of Vein

Selection of an appropriate vein and IV site was very important. The largest, softest, and most pliable vein was the best choice for avoiding IV infiltration\(^2^4\). Veins should always be palpated before cannulation. Characteristic of a good vein is:\(^^{3^1}\)

- Visible

- Soft and bouncy.

- Fills when it has been depressed.

- Straight.

- Has a large lumen.

#### 2.2.3 Size of Cannula and Site Selection

Select the smallest-gauge peripheral catheter that will accommodate the prescribed therapy and patient need. Consider a 20- to 24-gauge catheter for most infusion therapies and consider a 22- to
24- gauge catheter for neonates, pediatric patients, and older adults to minimize insertion-related trauma (4).

Study done by Park mentioned that a small gauge catheter results in fewer traumas to the vein (24).

Careful selection of appropriate site is essential to minimize the risk of infiltration and extravasation and limit the damage to tissues (12).

Site selection should be routinely initiated in the non-dominant arm start from distal areas of the upper extremities; subsequent cannulation should be made proximal to the previously cannulated site (32).

Site selection should avoid areas of flexion; areas of pain on palpation; veins that are compromised (e.g. bruised, infiltrated, scleroses, or corded); location of valves; and areas of planned procedures. In infants and children, avoid the hand or fingers, or the thumb/finger used for sucking although this may not always be possible in an emergency situation such as during resuscitation when the antecubital fossa is recommended (33). Choice of an alternative site due to infiltration/extravasation of solutions into the extremity should require assessment of the type of solution, its PH, osmolarity, the estimated volume infuse and the condition of the vein (34).

Journal of infusion nursing published practice criteria of site selection standard for paediatric patients to use the venous site most likely to last the full length of the prescribed therapy, considering veins in the hand, forearm, and upper arm below the axilla. Avoid the antecubital area, which has a higher failure rate. Some venous access sites listed as high risk of nerve injury. Standard 47 of INS, which are often used by nurses or anesthesia, include: (4)

The dorsal hand

The radial wrist

The inner wrist

These sites would ideally be avoided for I.V. access to prevent permanent nerve injury in patient.

Arterial access sites with the greatest risk of nerve injury include (4)
- The brachial artery
- The radial artery
- The axillary artery

Article by Doellman mentions factors contributing to the risk for infiltration and extravasation.

Mechanical factors include: Small size and poor condition of veins, larger catheter size relative to vein size, choice of site e.g. areas of joint flexion, dominant hand, unstable catheter, poor securing of IV access, patient activity, and multiple venipuncture sites. Pharmacological factors include: PH, osmolarity, vasoconstrictive potential\(^{(5)}\).

Study done in Ethiopia was aimed to assess the lifespan and associated factors of peripheral intravenous cannula among infants admitted in public hospitals of Mekelle city. Cannula size was obtained for 178 peripheral intravenous cannula insertions. Insertion was accomplished for 175 infants (98.3%) by 24 gauge cannulas. More than two-thirds, 118 (66.3%) cannulas were inserted in veins which were visible but not palpable. This study showed that the site of peripheral intravenous cannula placement was in the arm\(^{101}\) (56.7%) The duration of patency of peripheral intravenous cannulas \((n = 178)\) ranges from 1 to 96 hours\(^{(35)}\).

### 2.2.4 Flushing of cannula

INS standard of practice mention that vascular access devices shall be flushed prior to each infusion as part of the steps to assess catheter and after each infusion to clear the infused medication from the catheter lumen, preventing contact between incompatible medications. Short peripheral catheters should be locked with preservative-free 0.9% sodium chloride following each catheter use in adults and children\(^{(34)}\). A cross-sectional survey of nurses and midwives working in the State of Queensland, Australia was conducted the aim of the study was to improve understanding of current flushing practices for vascular access devices through a survey of practice. Most nurses reported using sodium chloride 0.9% for flushing both peripheral (96%) and central devices (75%). Concentration of heparin saline was used by 25% of those flushing central devices. Approximately half of respondents stated that there was no medical order or documentation for either peripheral or central device flushing\(^{(36)}\).

The prescribing information for Sterile Water for Injection states that it is sterile, non-pyrogenic water for injection intended only for dilution purposes. It has a PH of 5.4 and a
calculated osmolarity of mOsm/L. Sterile Water for Injection, is not intended for direct injection, the low tonicity will cause hemolysis of the cells and may be fatal. Therefore, it is contraindicated for intravenous administration without admixing\(^{(37)}\).

### 2.2.5 Securing the intravenous cannula site

The intravenous cannula site should be covered with a transparent plaster which assists security of the site, as well as allowing the site to be visible at all times\(^{(38)}\). The project was conducted in a 43-bedded general paediatric ward to address the poor visibility of the IV site due to bandaging caused by poor adhesive strength of the IV securement dressing. The post-implementation audit showed 100% visibility of the IV site, from 73% pre-implementation, and 87% compliance on frequent IV site inspection, from 70% pre-implementation. Both criteria attained 100% compliance during the sustainment audit. Incidences of extravasation and phlebitis were reduced from eight to seven; an improvement of 13%. This project has greatly improved the visibility of the IV site as well as nurses' compliance in checking the IV site. This is because nurses can monitor the IV site without having to remove any additional bandage over the site and causing unnecessary distress to fretful paediatric patients. The use of an adhesive transparent dressing can lead to prevention and earlier detection of extravasation. Additionally, the new IV securement dressing brought about manpower cost savings enabling staff time directed to other patient care activities. Dressings must be clean, dry and intact to prevent microbial contamination of the site. Change the PIVC dressing if it becomes damp, loose, or visibly soiled, and secure the PIVC and infusion tubing with tape, net or bandage, the site visible\(^{(39)}\).

An Evidence-Based Practice project was conducted at Cook Children’s Medical Center, Texas to improve securement and visualization of peripheral intravenous catheters in paediatric patients. A baseline audit of 90 PIVs on varying units identified the following practice: 40% of the PIV sites were not visible, clear dressings were only used 40% of time, and mean duration of PIV was 38.2 hrs. Outcomes 6 months post implementation following staff education indicated strong improvement in practice 95% of sites were clearly or easily visible, clear dressings used 92%, catheter stabilization devices used 74%, and mean duration of IV increased to 62.9 hrs. IV infiltration data indicated decreasing severity with earlier recognition and removal of IVs\(^{(40)}\).
2.2.6. Assessment of site of IV and rotation of cannula

In 2012, INS released a position paper on the frequency of assessing peripheral catheter sites. Observation of the insertion site is recommended at a frequency of every 1 to 2 hours assessment based on the type of fluids and medications being given\(^{(41)}\).

In the 2011 INS Standards, recommended frequency for site rotation of the “short” peripheral catheter based on clinical indications, rather than a specific time frame. Clinical indications include assessment of the patient’s condition and access site, skin and vein integrity, length and type of prescribed therapy, venue of care, and integrity and patency of the catheter\(^{(34)}\).

Center for disease control and prevention (CDC) Guidelines for the Prevention of Intravascular Catheter-Related Infections recommended that replace peripheral catheters in children only when clinically indicated.\(^{(42)}\)

A recent review analyzed data from seven randomized controlled trials that compared routine removal of peripheral IV catheters with removal only when clinically indicated in hospitalized or community patients receiving continuous or intermittent infusions. The authors found no evidence to support changing catheters every 72 to 96 h. Consequently, they suggested that healthcare organizations consider a policy in which catheters are changed only if clinically indicated\(^{(43)}\).

More recent studies have shown no difference in infection and phlebitis rates in cannula that are left in situ and only replaced when clinically indicated, compared to those replaced every 3 days. Therefore, EPIC recommends that peripheral cannula only need to be resited when clinically indicated and not routinely\(^{(44)}\).

Royal College of Nursing provides clinical guideline about peripheral intravenous cannulation in children stated that flushing with sodium chloride 0.9% w/v as per prescription taking into account the size and age of child, applying transparent, semi-permeable dressing to enable other practitioners to observe for inflammation, and changing the cannula after 72 hours\(^{(45)}\).
2.2.7. Insertion of cannula from first attempt

There is evidence that first attempt success directly related to peripheral intravenous catheter insertion knowledge, confidence, and skills \(^{(46)}\). Few intravenous lines in children are inserted successfully on the first try. Study of 593 attempts in centers with paediatric hospitalize services to estimate difficult venous access revealed that the average child required 2.2 sticks to achieve venous access, and that successful insertion took more than half an hour, and a third of children could not be cannulated even after two tries. Peripheral intravenous lines could not be placed at all in 5\% of cases \(^{(47)}\). A separate review of peripheral intravenous line insertions in children revealed that the first attempt was successful in just 53\% of cases, while 67\% were successful within 2 attempts and 91\% were successful within 4 attempts \(^{(48)}\). According to a previous study, the success rates of peripheral IV insertion performed on paediatric patients were 42.8\% for the first trial, 39.7\% for the second trial, 37.5\% for the third trial, and 38.8\% for the fourth trial these results indicate that the first trial success rate of peripheral IV insertion for paediatric patients is very low compared to that of adults, and the patients consequently become more vulnerable to IV infiltration and extravasation \(^{(49)}\).

2.2.8 Documentation of insertion of peripherals IV cannula

Nursing documentation is defined as that which encompasses all written and/or electronic entries reflecting all aspects of patient care communicated, planned recommended or given to that patient. The purpose of documentation to meet and exceed charting standards also protects nurses providing care from possible ties to negligence or malpractice. Documentation is often the sole point of communication between nurses of changing shifts \(^{(50)}\). Documentation is the keys to an effective legal defense in the event of a medico-legal Claim \(^{(51)}\).

Documentation shall reflect the continuity, quality, and safety of care. Includes: \(^{(52)}\)

- Date
- Time
- Name of nurse insert Iv cannula
- Site of cannula
- Size of cannula
- Number of attempt
- IV solution started
- Rate of infusion

### 2.3 Recognition of infiltration

Infiltration is reported with all types of peripheral and central vascular access devices and intraosseous devices. The nurse should routinely assess all vascular access sites for signs and symptoms of infiltration and extravasation based on patient population, type of therapy, type of device, and risk factors. The nurse should determine possible causes of infiltration and extravasation, which include mechanical, pharmacologic, obstructive, and inflammatory factors\(^{(53)}\). It is important for the nurse to be able to recognize the early signs and symptoms of infiltration and extravasation\(^{(12)}\).

Clinical features of IV infiltration include skin blanching, edema, skin cool to touch and pain\(^{(54)}\).

#### 2.3.1 Signs and symptoms of intravenous infiltration

The nurse should confirm the absence of all signs and symptoms of complications, such as:\(^{(55)}\)

- Pain
- Blanching at the cannula insertion site
- Tenderness / Discomfort
- Edema at, above, or below the insertion site
- Erythema at or above the insertion site
- Changes in the temperature of the surrounding skin (coolness)
- Damp or wet dressing
- Slowed or stopped infusion
- No backflow of blood into IV tubing on lowering the solution container
- Numbness, tingling, or a feeling of “pins and needles”
- Burning at the insertion site or along the venous pathway
- Fluid leaking from the insertion site
- Feeling of skin tightness around the insertion site or tightness below the site (such as in the fingers)
- Bruising

Article by Treadwell mentioned that children and neonates with darker skin are more likely to suffer from extravasation because of the difficulty visualizing the very small veins in this population\(^{(56)}\).

### 2.3.2 INS practice criteria

Limit the amount of solution that enters the tissue through early recognition of signs and symptoms of infiltration/extravasation. Signs and symptoms progress from simple to complex, and the clinical presentation:

- Pain may be the initial symptom and may be sudden and severe when associated with a rapid injection of solution or medications; may be out of proportion to the injury; may appear with passive stretching of the muscles in the extremity; pain intensity may increase over time.

- Edema may appear as a raised area under the skin near the peripheral VAD site or as an enlarged and tense extremity due to fluid accumulating in compartments of the extremity. Compare circumference of both extremities.

- Changes in color may include blanching from non-vesicant solutions; vesicants can produce redness; however, extravasation into deep tissue may not produce visible color changes.

- Fluid leakage from the puncture site. - Blister formation may appear within hours (e.g., contrast media) or may be delayed for days with antineoplastic agents. Progression to ulceration may vary from a few days to 1 to 2 weeks, depending upon the medication that extravasated\(^{(4)}\).
2.4 consequences of IV infiltration and extravasation

The nurse should monitor clinical outcomes associated with infiltration, which may include: compartment syndrome with the need for rapid surgical intervention, and nerve injury from excessive compression producing neuropathies and complex regional pain syndrome. While clinical outcomes associated with extravasation that may include formation of blisters over a prolonged period (e.g. 7-14 days), skin sloughing and tissue necrosis, and loss of limb (57).

The literature uses separate terms to refer to fluid escape from IV catheters and peripheral veins and subsequent pooling of fluid in the surrounding tissue. The major difference between infiltration and extravasation is the type of fluid infused (58).

Quality improvement project was to achieve a 10% decrease in the baseline infiltrate rate on two inpatient units and in the overall infiltrate rate across all of the paediatric units. Major and Huey reported that the infiltration rates before and after the improvement strategies focused on evidence-based education, and intravenous (IV) catheter securement. Positive results across all units were revealed, with the number of events (n = 51 pre; n = 19 post) and the infiltration rates (13.5 pre; 7.1 post) decreasing over a three-month period. A decrease was also noted in the overall percent of IVs that infiltrated in the first 24 hours (45% pre; 42% post). There was a statistically significant difference (t = 15.16; p < 0.001) between the nurses’ knowledge before (n = 57; mean = 61.75; SD 14.16) versus after the educational intervention (n = 57; mean = 92.11; SD = 8.40) (59).

A study done by Park et al. aimed to identify the effect of IV infiltration management program among hospitalized children. It developed an IV infiltration prevention and early detection program. The program consisted of a poster, documentation of catheter insertion, and completion of an infiltration report, vein assessment before catheter insertion, appropriate site selection, and assessment of the insertion site every shift. Study found that the most common intravenous insertion site was the back of the hand, with 48.8% of the comparison group and 50% of the experimental group. The location of the greatest difference between the two groups was the wrist, with 7.9% for the comparison group and 20.6% for the experimental group. For the size of the IV catheters, 24 gauge was used more frequently than 22 gauge and there was no significant difference in the effect of the size of
IV catheters between the two groups. The most frequently injected fluid was 5% dextrose with 59.7% of the comparison group and 44.1% of the experimental group. The most frequently administered antibiotic was cefotaxime, including 48.0% of the comparison group and 29.4% of the experimental group\textsuperscript{(24)}. The purpose of the evidence-based practice change project was to implement best practice guidelines for the prevention and assessment of peripheral IV complications, resulting in an increase in the level of knowledge among paediatric nurses in managing them. The project included a comprehensive educational plan focused on evidence-based guidelines for paediatric peripheral IV site care and increasing the frequency of assessment for short peripheral catheters from every 2 hours to every 1 hour. The project was implemented in a 296-bed, urban academic medical center that specializes in the treatment of paediatric patients. A 25-bed medical/surgical unit was designated for the project. The participant group’s mean pretest score for knowledge was 87.27%; the posttest mean score was 97.27%. A test of mean differences showed statistical significance in mean test scores for knowledge from the pretest to the post test (\(T = 4.06, P = .001\)). Taylor reported that the infiltration rates before and after the evidence-based education that was provided to nurses to reduce paediatric infiltration was 20.0% and 11.8%, respectively\textsuperscript{(60)}.

### 2.5 Assessment and grading infiltration scale

The nurse should use a standardized scale for assessing and documenting infiltration/extravasation from all types of vascular access devices. This measurement should occur initially and regularly until resolution, based on patient condition and age; type of fluid; severity of infiltration/extravasation; type of device; and anatomical location.\textsuperscript{(34)} A grading scale is recommended for assessing and determining the extent, standardizing the description of the infiltration, documenting the severity of the problem, and evaluating the degree and prevalence of infiltration\textsuperscript{(4)}. Currently, scales have also been used as indicators to assess the outcomes of care and to support the implementation of interventions\textsuperscript{(33)}. The Infusion Nurses Society developed a grading scale to assess damage caused by infiltrations. The most severe complication present should determine the grade of infiltration, and infiltrations involving vesicants should automatically be considered grade 4\textsuperscript{(61)}. Initial IV infiltrates are typically evaluated first by nursing staff and often graded according to a scale that has been adopted by their facility. Systematic approaches to infiltrations are helpful in
communicating the severity of the event and in determining the course of action necessary for intervention (62).

A quality improvement project conducted by a safety event response team at Cincinnati Children’s Hospital Medical Center found a significant decrease in infiltration rates immediately following an educational intervention to promote hourly peripheral IV site assessments using TLC (touch, look, compare). This method recommended the standardized process of touching the site to identify pain, swelling, or temperature change (12).

2.5.1 Clinical criteria of INS intravenous infiltration scale (34).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Infiltration Grading Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No symptoms</td>
</tr>
<tr>
<td>1</td>
<td>Skin blanched -Edema &lt; 2.5cm -Cool to touch +/- pain</td>
</tr>
<tr>
<td>2</td>
<td>Skin blanched -Edema 2.5cm-15cm -Cool to touch +/- pain</td>
</tr>
<tr>
<td>3</td>
<td>Skin blanched, translucent -Gross edema &gt; 15cm -Cool to touch -Mild-moderate pain -Possible numbness</td>
</tr>
<tr>
<td>4</td>
<td>Skin blanched, translucent -Skin tight, leaking-Skin discolored, bruised -Gross edema &gt; 15cm Deep-pitting tissue edema -Circulatory impairment -Moderate-severe pain</td>
</tr>
</tbody>
</table>

The use of a scale enables early identification of the first signs and symptoms of infiltration, and a quick approach to the initiation of treatment and prevention of damage. The first intervention when identifying any degree of infiltration must be immediate removal of the catheter (63).

A study conducted at paediatric Children’s University Hospital in Mansoura city, Egypt. The participants were hospitalized children (253) from less than one year to 16 years who received peripheral IV insertions. The results indicated that the infiltration rate was 23.3% and it was from stage 1 and 2. And the most important risk factors for infiltration were previous experiences of insertion of peripheral catheter, site of insertion, catheter size, repeated insertion on the same site, infusion of antibiotics and IV fluids (64).
The absence of a uniform scale increases the likelihood of miscommunication and irregularities in treatment that can lead to litigation, extension of hospital stays, and increased cost of these stays\(^{(11)}\).

Universal IV assessment guidelines and clearly defined grading scales for infiltrates are crucial to prevention and effective management of IV infiltrates\(^{(65)}\).

A retrospective cohort study carried out at a university hospital, with 338 children with peripheral intravenous catheters, the aims were to compare characteristics of children with peripheral intravenous catheters who developed infiltration and those who did not and to identify risk factors for developing this complication. Researchers identified infiltration in 54 children (16%). Characteristics statistically different in those who developed infiltration were the following: intravenous therapy for more than 5 days, presence of predisposing factors to peripheral venepuncture failure, history of previous infiltration, catheter readjustment to vein insertion, use of infusion pump, intermittent administrations, and shorter dwell time\(^{(66)}\).

Quality improvement project at Arnold Palmer Hospital for Children, United States creating an educational awareness program for both staff nurses and families using the S.T.I.C.K. mnemonic bundle represented the five components of the prevention bundle, each having their own educational materials. How to properly tape and secure an IV, recognize signs and symptoms of infiltration, identify common irritating IV medications, and educate and involve families in the surveillance of an IV. Additional education was provided during huddles regarding how to choose the most appropriate catheter size for their patient.

S: a standardized step by step approach to securing the IV focusing on the type of tape used as well as how the tape is to be applied

T: touch, look, and compare was an acronym noted in the literature

I: irritants focused on the list from pharmacy.

C: catheter selection used an algorithm for determining the need for a midline IV access.

K: keep it?

Rates of PIV catheter infiltration on a paediatric medical-surgical orthopedic and neurology unit were found to decrease when staff nurses utilized the S.T.I.C.K. mnemonic bundle while managing PIV catheter care for paediatric medical-surgical and neurology patients\(^{(67)}\).
2.6 Treatment of intravenous infiltration

Universal IV assessment guidelines and clearly defined grading scales for infiltrates are crucial to prevention and effective management of IV infiltrates. The most important factor in the treatment of infiltration is preventing an adverse event from occurring in the first place. Depending on the agent to be infused and the length of time that IV medication is needed. Staff should notify the pharmacy when using short peripheral catheter so that dilution can be adjusted for administration. If nursing staff elects to use a short peripheral catheter, the staff should carefully monitor each catheter insertion site to prevent infiltration (62).

2.7 Extravasation

Extravasation is inadvertent leakage of a vesicant solution into surrounding tissue. A vesicant refers to any medicine or fluid with the potential to cause blisters, severe tissue injury (skin/tendons/muscle) or necrosis if it escapes from the intended venous pathway (34). Extravasation injuries initially present as local swelling, erythema, blistering, and pain. These injuries can lead to severe and progressive destruction of the tissue, including tissue necrosis, and can ultimately interfere with the function of the affected extremity or result amputation. Therefore, injuries resulting from extravasation are considered to constitute a medical emergency and necessitate immediate treatment. The nurse is the key to reducing the risk of extravasation, through her knowledge and skill in cannulation and the intravenous administration of drugs. The nurse must also be able to recognize the early signs and symptoms of extravasation and act promptly and effectively to limit tissue damage. Finally, accurate documentation of the event is vital to facilitate patient care and in case of litigation (6).

2.7.1 Signs and symptoms of extravasation (34).

- Blanching
- Burning, or discomfort at the I.V site
- Cool skin around the I.V site
- Swelling at or above the I.V site
- Blistering and/or skin sloughing
A study was done among 60 nurses to assess the existing knowledge and Practice of staff nurses on prevention and management of extravasation among Infant receiving I.V. The study findings revealed that majority 40 (66.7%) of the staff nurses have moderate knowledge, 58 (96.7%) of staff nurses had good practice.

2.7.2 Mechanisms of tissue injury in infiltration and extravasation due to Pharmacologic factors

- PH

- Osmolarity

- Vasoconstrictive agent

Solutions that irritate the venous endothelium and vessel wall ultimately raise the risk of venous rupture, allowing the solutions to escape into the surrounding tissue. To minimize venous irritation, infused solutions should be close to physiologic PH (7.35-7.40) and osmolarity (281-282 mOsm/L).

Extreme PH (both alkaline and acidic) can reduce peripheral vein tolerance by damaging cell proteins and eventually causing cell death, leading to venous endothelial damage and making it susceptible to rupture. The PH of infusion solutions should generally be between five and nine.

Fluids and medications with an osmolarity greater than 350 mOsm/L are considered hypertonic. Those with an osmolarity greater than 600 mOsm/L should not be infused through a peripheral vein the central route should be used.

2.7.3 Administration of vesicants

The patency of the vein and catheter must be assessed prior to administering vesicant drugs/fluids. The line should be flushed to determine if any resistance is felt and there should be a brisk, free flowing blood return into an empty syringe, and slow or inadequate blood return could indicate a problem. Concentration of vesicant, the amount extravagated, and the types of vesicant are all factors which will influence the severity of the extravasation. The degree of injury ranges from mild skin reaction to severe necrosis.
2.7.4 Vesicant drugs and solutions reported to cause extravasation injury \(^{(56)}\).

There are different vesicant medications and solutions that were reported to cause extravasation injuries. Non-cytotoxic medications associated with extravasation injuries.

**Commonly used IV antibiotics:**

- Vancomycin
- Aciclovir, Gancicolvir
- Gentamicin
- Phenytoin
- Amphotericin
- Cefotaxime

**Vasocompressive agents**

- Dobutamine
- Dopamine
- Epinephrine (adrenaline)
- Norepinephrine (noradrenaline)
- Vasopressin

**Concentrated electrolyte solutions**

- Potassium chloride 7.45%
- Sodium bicarbonate 4.2\% & 8.4\%..
- Sodium chloride 10%
- Calcium chloride
- Calcium gluconate 10%

**Hyperosmolar agent**

- >10% dextrose
- Mannitol 15%
- Other medications like Diazepam, Digoxin and Phenobarbital.

The nurse is the key to reducing the risk of infiltration and extravasation, through her/his knowledge and skill in cannulation and the intravenous administration of drugs. The nurse must also be able to recognize the early signs and symptoms of infiltration and extravasation and act promptly and effectively to limit tissue damage. Lack of knowledge regarding non-cytotoxic medications might increase the risk of extravasation\(^6\).

A study done in an academic medical center, Yangsan, Republic of Korea. Aimed to examine the cumulative risk for infiltration over IV catheter dwell time by general or catheterization-specific characteristics of paediatric patients with IV therapy. Data analysis was done with the data of 1596 children who received peripheral IV therapy at least once during their hospital stay. The cumulative risk for infiltration had rapidly increased from 1.5% after 24 hours of catheter dwell time to 17.3% after 96 hours. The survival functions were significantly different in the medical than in the surgical department (p=.005), lower extremities than upper ones (p=.001), and use of 10% dextrose (p=.001), ampicillin/sulbactam (p<.001), vancomycin (p=.024), high-concentration electrolytes (p=.001), and phenytoin (p<.001)\(^7\).

A study was done by Mo’men Sisan to assess the knowledge level regarding non-cytotoxic medications extravasation and its associated factors among staff nurses. A descriptive correlational design using self-administered questionnaire was employed. A convenience sample of 387 nurses completed a questionnaire about non-cytotoxic medication extravasation. The results indicate that only 19.6% of nurses have a good knowledge about non-cytotoxic medications extravasation. There was consistently poor staff knowledge regarding non-cytotoxic medications extravasation. Although the closed units' nurses reported relatively higher level of knowledge than open units' nurses, their level of knowledge still inadequate\(^7\).
Article by Tong about management of extravasation injuries which include, education for nursing staff on the signs and symptoms of extravasation, assessment of intravenous cannula sites hourly, nursing protocols for IV administration and record keeping. He mentioned that the common sites of extravasation injuries in neonatal and paediatric patients include the dorsum of the hand, the forearm, the cubital fossa, and the dorsum of the foot. These are the areas of the body where the skin and subcutaneous tissue are thinnest, which makes them the most susceptible to injury.\(^{73}\)
A study done by George and Muninarayanappa to assess effectiveness of structured teaching program on knowledge and practices of staff nurses on prevention of intravenous cannula complications. A quasi-experimental approach; a non-probability convenient sampling technique was adopted to select 80 staff nurses, each 40 in experimental and 40 in control group. 67.79% of patients developed peripheral intravenous cannula-related complications with grade 1 (33.05%) and grade 2 (34.74%) complications. Result revealed that it was highly significant at 0.05 level (t = 9.978; P < 0.05) for knowledge and not significant (t = 0.974; P > 0.05) for practice. The post-test knowledge found to be highly significant at 0.05 level (t = 3.909; P < 0.05), whereas practice score was not significant (t = 0.426; P > 0.05). It could be inferred that there is no significant difference between the pre-test and post-test practice score of staff nurses who attended the structured teaching program regarding prevention of intravenous cannula complications.

In a study done to describe the incidence of extravasation at a paediatric tertiary care hospital, to identify the agents causing extravasation, and to describe the use of antidotes to manage identified cases, the medical records of paediatric patients with documented extravasation of an IV medication were used. A total of 42 patients had documented extravasation, for an overall incidence of 0.04% per patient-day. Of the 40 cases in which location was documented, 12 (30%) occurred on the general paediatric wards, 10 (25%) on the surgical ward, 9 (22%) in the neonatal intensive care unit, 5 (12%) in the paediatric intensive care unit, 3 (8%) in day care, and 1 (2%) in the emergency department. The most common medications involved were fluids for IV administration (43%), potassium chloride (26%), antibiotics (19%), and total parenteral nutrition (19%), Calcium chloride (5%), and epinephrine (5%). Multiple drugs were involved in some cases of extravasation. The decision to administer an antidote and the choice of antidote (if required) were appropriate in 50% of the cases.

Extravasation of Vasocompressive agents e.g. Dobutamine, Dopamine, Epinephrine, Norepinephrine, and Vasopressin can result in ischemic necrosis because these substances reduce blood flow by causing severe constriction of smooth muscles around capillaries and solutions with high electrolyte concentrations e.g. Calcium Chloride 5.5% or Sodium Chloride 3% or 5% can prolong the depolarization and contraction of pre- and post-capillary smooth muscle sphincters, which, in turn, prolongs exposure to injurious substances and leads to ischemia and tissue necrosis.
Article by Bhosale, mentioned case report of extravasation injury due to Dopamine infusion lead to dermal necrosis and gangrene (76). A study was done to determine the prevalence of infiltration and extravasation among children staying in a children's hospital and the interventions carried out when infiltration or extravasation occurred. The study sample consisted of 297 peripheral catheters in 173 paediatric patients. Of 297 peripheral catheters, 50.8% were located on the right and 30.6% were inserted in the dorsal metacarpal vein. Infiltration and extravasation occurred in 2.9% and 2.3% of the patients, respectively. The prevalence of infiltration and extravasation was 5.5 and 4.4 per 1000 patient-days, respectively. The applied interventions after infiltration or extravasation included covering with a gauze dressing or alcohol-soaked cotton, cold application, irrigation with physiological saline, and elevation. The infiltration and extravasation prevalence were found to be high, but the interventions to address them were inadequate. Training and implementation strategies should be planned for paediatric nurses to prevent infiltration and extravasation (77).

A study was done in China to explore the incidence, risk factors, characteristics and treatment outcomes of extravasation injuries resulting in drug extravasation among Chinese children. The children undergoing infusion therapy (0-18 years) were enrolled in this study in Shanghai Children’s Hospital. The patients’ information including age, gender, injection site, estimated volume of solution extravasated, patient symptoms, severity of extravasation injury, treatment methods, and outcomes was collected. The incidence of extravasation in paediatric patients was 1.79% (18/1,004). The severity of extravasation was labeled with grade range from Grade 1 through Grade 4: four cases with Grade 1, eight cases with Grade 2, five cases with Grade 3, and one case with Grade 4. The risk factors of extravasation include infused high volume/day (≥1000 ml), received operation, and infused agents with high osmolarity and poor vein condition. The severity of extravasation was related to the large volumes of drug or special drugs (high-osmolarity, high-risk, low PH, etc). All extravasation were treated with physical, pharmacological and surgical intervention (skin grafts and flaps) according to hospital standard operation protocols. Systematic implementation of intervention can alleviate the extravasation injuries and improve the patients’ outcome. Infused high volume per day, received operation, infused agents with high osmolarity and poor vein condition increased the risk of extravasation (78). Educational program was done for nurses on prevention and management of neonates regarding Peripheral Intravenous complication, the findings of the current study showed that there is an
improvement in nurses knowledge and practice about neglecting items between pre and post-
program mean scores and there were highly statistically significant differences (P < 0.001)
between pre and post-program implementation and there was statistically significant positive
correlation between nurses’ total knowledge scores before program implementation and their
practice after program implementation(79).

2.8 Nursing intervention when infiltration or extravasation occurred

All healthcare organizations should have a policy in place relating to the recognition,
prevention, and management and reporting of extravasation of both cytotoxic and non-
cytotoxic drugs(80).

A review of prevention and management of infiltrations done by Doellman et al. suggests
five steps at the first signs of infiltration: stop administration of fluids, disconnect IV tubing
from catheter, attempt aspiration of residual drug from catheter site, and notification of the
physician. Nursing interventions included elevation and thermal application; local thermal
treatments are used to decrease the site reaction and absorption of the infiltrate. Local
cooling (ice packs) aids in vasoconstriction, thus theoretically limiting drug dispersion. Cold
application is recommended for extravasation of DNA-binding vesicants .The use of local
warming is recommended for extravasation of non–DNA-binding vesicants. Although clear
benefit has not been demonstrated with thermal applications, it remains standard supportive
care, and the recommended application schedule for both warm and cold applications is 15
to 20 minutes, every 4 hours, for 24 to 48 hours. It should be noted that heat and cold
applications are not well supported in neonates and young infant(5).

Study recommends basic interventions for infiltration that include: aspiration from the
cannula, removal of the cannula, elevation, and application of heat or cold. Although most
injuries will heal without intervention, there are wide ranges of treatment options for
intravenous infiltrations and extravasation that include: elevation, application of heat and/or
cold, medications, dressings, debridement, and skin replacement in sever extravasation(81).

Prevention strategies suggested by Amjad et al. include a minimum of hourly assessments,
appropriate taping techniques to allow adequate visibility of insertion site, and infusions run
on automated pumps with pressure sensors. It is a consensus that frequent and routine
evaluation of the catheter site and early recognition of infiltration is important to minimize
risk of tissue damage(62).
An article by Hadway described prevention and management of extravasation from a peripheral catheter. She adheres strictly to proper administration techniques and follows guidelines by: (82) - Ensuring that the drug has been properly diluted before injection or infusion. Dilution reduces the amount of vesicant that will reach subcutaneous tissue if extravasation occurs. It also helps detect edema or complaints of pain before the entire dose is administered.

- Selecting a small-gauge catheter to minimize trauma to the vein and let enough blood flow around the catheter to hemodilute vesicants.

- Selecting the venepuncture site carefully, using a distal vein

- Not using the dorsum of the hand, the wrist, fingers, antecubital fossa, or other areas of flexion; previously damaged areas; or areas with compromised circulation.

- Not probing for a vein. If you don’t penetrate it immediately, stop and begin at another site.
- Not administering a vesicant at an I.V. site that’s more than 24 hours old; the vein may already be irritated. Perform venepuncture at another site so you can ensure correct needle or catheter placement and vein patency.

- Securing the catheter properly and covering the venepuncture site with a transparent dressing.

- Immediately before giving each dose of the drug, or every 1 to 2 hours for a continuous infusion, assessing the site to reconfirm vein and catheter patency. - Gently flush the catheter with 0.9% sodium chloride solution while palpating the site to detect edema.

- Checking for infiltration before starting the vesicant infusion by applying a tourniquet above the catheter to occlude the vein and seeing if the I.V. solution continues to flow despite the tourniquet. If so, it’s infiltrating into tissue.

- During the infusion, observe the site for erythema or edema.

- After the infusion is complete, use 0.9% sodium chloride solution to flush the tubing and catheter.
3. Methodology:

3.1 Study design:

An Interventional pre-post training hospital-based study

3.2 The study area:

The study was carried out in Khartoum state, which consists in fact of three cities: Khartoum, Khartoum North (Bahri), and Omdurman. Khartoum State lies at the junction of the two rivers, the White Nile and the Blue Nile in the North Eastern part of central Sudan. Khartoum city is also the national capital of Sudan. Khartoum's state composed of seven localities: Ombadah, Karary, Omdurman, Bahri, Sharqe Elneel, Gabal Awlia and Khartoum Locality. The State is prevailed with a hot to very hot climate with rainy season during the summer and warm to cold dry winter\(^{(83)}\).

3.3 Study setting:

The study was conducted in children- governmental hospitals which are:

- Ahmed Gasim Children's Hospital
- Mohammed Elamin Hamid Children's Hospital
- Gafaar Ibn Auf Children's Referral Hospital
- ELbuluk Children's Hospital

Included staff nurses working in wards, an accident and emergency, high dependency units and intensive care units.

3.3.1 Ahmed Gasim Children's Hospital: Is one of the major general paediatric hospitals in Sudan; it is located in Khartoum North (Bahri City), Khartoum State. West of it AL-Ma-Una Street and AL-Mzad Street at East. AL–Zaim AL-azhari Street Southern of it and North about it Saad Gishra Market. It established 1993; it receives different referred cases from Khartoum State and other states of Sudan. The capacity is 98 beds .It contains outpatients (emergency and cold cases), paediatric intensive care unit with seven beds, high
dependency unit with eight beds, seven general paediatric wards. The admissions rate of hospital was about 4,764 annually.

3.3.2 Mohammed Elamin Hamid Children's Hospital:

Is located in Omdurman City, South East of Omdurman. South of it is a Museum of the Khalifa's house and north of it is AlShohada Station. West of it is Omdurman Teaching Hospital and at the east AL Mulazmin District. It is a teaching hospital that mainly serves Omdurman residents, in addition to cases referred from Khartoum State and other Sudan states. Established in 1986 the capacity are 350 beds. It contains nursery, intensive care unit (PICU), haemodialysis unit, X-ray and Ultrasound units, ECG & ECHO units, general paediatric wards, Central Blood Bank and Laboratory. Statistic unit with a modern set-up, the isolated ward for infectious diseases, and physiotherapy department. The admissions rate of hospital was about 5,164 annually.

3.3.3 Gafar Ibn Auf Children's Referral Hospital:

It is located in Khartoum started out as Sudan's first Paediatric Hospital in 1977. It was renamed Dr. Gaafer Ibnauf Specialized Hospital in 2002. It is bordered by AL Hawadth Street from south and AL Maknimir from east and AL Sayed Adurhman from the north. It receives different referred cases from Khartoum and other states of Sudan. Its capacity is 350 beds. It has a neonatal intensive care unit (NICU), paediatric intensive care unit (PICU), hemodialysis unit, Gastrointestinal tract (GIT) unit, cardiology unit and general paediatric wards. The admissions rate of hospital was about 4,920 annually.

3.3.4 ELbuluk Children's Hospital:

Is located in north of the Omdurman Karari locality, Alhara Alrabiaa bordered by ALshengiti Street from the west and ALthwra Belnos from east. Its capacity is 169 beds. It contains the Nursery Unit with five incubators, High Dependency Unit with six beds, suite with eleven beds, two general wards, and malnutrition ward. Thirty six beds in an accident and emergency department and Vaccination department. The admissions rate of hospital was about 3,640 annually.

3. 4 Study population:
The target population included staff nurses with nursing certificate, diploma, BSc and MSc, working in children's governmental hospitals.
3.4.1 Inclusion criteria

Nurses working in children's governmental hospitals with a permanent job.

Nurses with experience one year and above in children care.

3.4.2 Exclusion criteria

- Nurses under training
- Nurses recruited in national service
- Nurses who refused to participate in the study.

3.5 Sample Size and sampling technique:

3.5.1 Sample size:

The sample size was calculated according to Glenn D. Israel formula. \(^{(84)}\)

\[
 n = \frac{N}{1+ (N-1) e^2}
\]

\(n\) : is the desirable sample size

\(N\): is the population size

\(e\): is the degree of accuracy desired (the accepted margin of error and is usually set to 0.05)

\[
 n = \frac{280}{1+ (280-1) 0.0025} = \frac{280}{1.70} = 164.7
\]

The sample size of this study were 165 nurses by using above formula

3.5.2 Sampling technique:

Simple random sampling technique (probability sampling) was used to select the samples as per the inclusion criteria in the study.
3.5.3 Proportion used to determine the sample size of nurses from each hospital as:

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Population</th>
<th>Proportion %</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmed Gasim Children's Hospital</td>
<td>50</td>
<td>18 %</td>
<td>29</td>
</tr>
<tr>
<td>Mohammed Elamin Hamid Children's Hospital</td>
<td>130</td>
<td>46%</td>
<td>77</td>
</tr>
<tr>
<td>Gafar Ibn Auf Children's referral Hospital</td>
<td>44</td>
<td>16%</td>
<td>26</td>
</tr>
<tr>
<td>ELbuluk Children's Hospital</td>
<td>56</td>
<td>20%</td>
<td>33</td>
</tr>
<tr>
<td>Total number of nurses</td>
<td>280</td>
<td>100%</td>
<td>165</td>
</tr>
</tbody>
</table>

Each staff names were given a number according to their frame in hospital, and then the names listed in the separated numeric list to any hospital, then numbers collected and selection done randomly to decide participants included in the study according to the proportion of hospital from the total sample size.

3.6 Variables under Study

3.6.1 Independent variables:

- Age, sex, years of experiences and qualification level.
- Training program regarding prevention of IV infiltration and extravasation

3.6.2 Dependent variables:

- Nurse's knowledge regarding prevention of IV infiltration and extravasation. E.g. insertion site of cannula, secure of cannula, solution for flush cannula and recognition of infiltration and extravasation.
- Nurses' Practice regarding prevention of IV infiltration and extravasation. E.g. Visibility of insertion site, number of insertion attempts and grading of intravenous infiltration and extravasation.
3.7 Data collection tools:

3.7.1 Tool (1): structured interview questionnaire face to face (pre/post)

Structured interview questionnaire with closed ended questions according to Infusion Nurses Society’s (INS) was designed to study nurses’ knowledge regarding prevention of intravenous infiltration and extravasation among children. It was composed of three sections covering different aspects of knowledge regarding prevention of IV infiltration and extravasation.

Section one: It included questions designed to obtain information about demographic data about nurses.

Section two: It included questions designed to obtain information about preventative measures of IV infiltration and extravasation.

Section three:

It included questions designed to obtain information about recognition of IV infiltration and extravasation.

3.7.2 Scale system:

According to Likert scale three points scored, from one to three, 3 being good, 2 for fair and 1 for poor for each question has an answer with more than or equal to three values. Good and poor for each question has an answer of two options YES or NO.

3.7.3 An observational Checklist:

Modified checklist based on Infusion therapy Standards of Practice, which developed by Infusion Nurses Society (INS) The standards are based on scientific evidence, to measure practice of nurses regarding insertion of cannula, checking of the peripheral IV site condition, measuring and grading infiltration and extravasation occurrence. Scoring of the observational checklist modified by researcher and utilized to assess nurses practice regarding prevention of infiltration and extravasation .The practice scored from one to three, 3 being good if skill done correctly, 2 for fair if skill done not correctly and 1 for poor if skill not done.
3.8 Pilot study:

This was done to test clarity, applicability, feasibility and relevance of the tools used. The pretest was obtained by evaluating 10% of study the sample. Piloting showed minor defects in some questions a modification on tools was made based on the results. Hence, pilot study sample was excluded from the final sample. Pearson correlation coefficient by using Alpha Cronbach test ($r = 0.94$) for nurses level of knowledge and ($r = 0.87$) for nurses’ practice.

3.9 Data collection technique:

Data was collected by the researcher in three phases, before data collection the researcher declared for training program by nursing administrator (Matron) at study areas, the study participants were asked for their consent. Data collected firstly using a predesigned and pre-coded structured interview questionnaire to assess the knowledge and observation checklist for nurses’ practice, then training program was implemented according to Infusion Therapy Standards of Practice developed by infusion of nurses’ society (INS).

Three months later, after program implementation data was recollected again using the same structured interview questionnaire and an observational checklist.

3.10 Educational program

Contents of training program:

- Anatomy of vein
- appropriate site selection
- assessment of peripheral catheter insertion site
- assessment of vein condition before inserting cannula or administered medications
- documentation of catheter insertion
- training of nurses staff about signs & symptoms of I.V infiltration and extravasation
- Apply of I.V infiltration INS scale and grading rate of infiltration
- Documentation of IV infiltration and extravasation
3.10.1 Phase 1:

(Program of 1st day 9a.m - 1.00 pm.)

9.00a.m -10.a.m

Assessment phase the nurses’ baseline level of knowledge and the practice concerning preventive measures, recognition of IV infiltration and management of IV infiltration and extravasation tested by using a structured interview pretest questionnaire and an observational checklist before provision of any information. After collection of pretest data, the participants received the training program.

3.10.2 Phase 11:

11:a.m.-1p.m.

The training program developed by the researcher, based on the Infusion Nursing Stander of Practice and adopting the INS intravenous infiltration scale. The program activities were implemented by the following training methods:

- Lecture illustrated with power point presentation.
- Demonstration.
- Videos.
- Small group discussion.

The participants were divided into groups, not more than six nurses per session.

The first session was conduction of the theoretical part was performed through interactive lecture and group discussion and videos; the session lasted for 30-45 minutes and covered the following items:

The practical part of the program was provided through two sessions, one hour for each.

First station on program consists of:

- One hour interactive lecture using power point presentation of preventative measures of IV
infiltration and extravasation included knowledge about, cannula size, cannula site, documentation of insertion cannula included date, time, name of nurse inserted cannula and 0.9% saline to flush IV cannula.

- Identify the presence of IV infiltration and extravasation.
- Recognition of INS scale of infiltration.
- Identification of infiltration grading scale.
- Medication potential to cause extravasation.
- Videos contain IV cannula insertion and IV infiltration and extravasation was shown in addition to pictures to recognize infiltration and extravasation.
- Video for flushing technique displayed.

**Second station consists of:** The practical part of program. It took two hours included:

- Selection of cannula size, selection of site, documentation of insertion cannula, secure of cannula by transparent plaster, keeping the insertion site visible and assessing function of IV cannula by using 0.9% saline.

- Infiltration scale score sheet was given to nurses to determine the stage of infiltration by using measuring tape and how to document score.

- Demonstration using the Mannequin arm station, the mannequin arm station gave hands-on practice.

- TLC Touch site (for coolness, pain), Look swelling, blanching, blister at the insertion site. Compare both extremities, this method used for detection of IV infiltration.

- Immediate intervention when infiltration or extravasation occurred.

The program was presented in a clear, concise and simplest manner using the English language and explained in Arabic language and it focused on the point to be learned.

**3.10.3 Phase 111:**

**Program evaluation:**
After three month evaluation of the training program done, data collected again to assess level of knowledge and practice of nurses on prevention of IV infiltration among the same group and the same questionnaire and an observational checklist was used as follow-up phase.

3.11 Data management and analysis

All answers were checked for completeness in the field. Manual coding was done to check any error. Data collected were analyzed using the computer Statistical Package for Social Sciences (SPSS) program version 20. Data presented in tables, figures, mean and standard deviation (SD), and paired t test for testing differences between pre and post program as inferential statistics. P value 0.05 was considered statistically significant at 95% confidence level.

3.12 Ethical consideration

Ethical approval letters from both the research committee in AL Neelain University and from Ministry of Health ethical committee of research office. Approval from administrative authorities of hospitals and verbal agreement from participants obtained.

Before starting interviewing the participants’ consent were secured from participants after explanation of aim of the study in clear simple words. The participants in this study assured confidentiality through identification coding. Questionnaire and training program were completed in the break for nurses rest time without any interruption to work.
4. Results

Figure I. Gender of the participants.  n=165
Figure II. Age of the participants. n=165
Figure III. Qualifications of the participants. n=165
Figure IV. Working experience of the participants in years.  

n=165
Figure V. In-service training in intravenous therapy.  n=165
Table 1. The participants’ level of knowledge pre / post program about site selection. n=165

<table>
<thead>
<tr>
<th>Site selection</th>
<th>Pre intervention Frequency%</th>
<th>Post intervention Frequency%</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>90(54.5%)</td>
<td>43(26.1%)</td>
<td>-5.901 -</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>6(3.6%)</td>
<td>0(0.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>69(41.8%)</td>
<td>122(73.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. The participants’ level of knowledge pre / post program after insertion of cannula. n=165

<table>
<thead>
<tr>
<th>Knowledge statements</th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

52
<table>
<thead>
<tr>
<th></th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>115(69.7%)</td>
<td>3(1.8%)</td>
<td>-27.453</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>40(24.2%)</td>
<td>26(15.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>10(6.1%)</td>
<td>136(82.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. The participants’ level of knowledge pre / post program about documentation of insertion cannula. n=165
Figure V1. The participants’ level of knowledge pre / post program about definition of intravenous infiltration. n = 165
Table 4. The participants’ level of knowledge pre / post program about identification of intravenous infiltration.  n = 165

<table>
<thead>
<tr>
<th></th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>126(76.4%)</td>
<td>10(6.1%)</td>
<td>-21.321</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>17(10.3%)</td>
<td>8(4.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>22(13.3%)</td>
<td>147(89.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5. The participants’ awareness pre /post program about infiltration scale.

n = 165

<table>
<thead>
<tr>
<th></th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0(0.0)%</td>
<td>158(95.8%)</td>
<td>60.842</td>
<td>0.001</td>
</tr>
<tr>
<td>No</td>
<td>165(100.0%)</td>
<td>7(4.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6. The participants’ level of knowledge pre / post program about infiltration grading scale.  

<table>
<thead>
<tr>
<th></th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>165 (100.0%)</td>
<td>20 (12.1%)</td>
<td>-25.439</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>–</td>
<td>64 (38.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>–</td>
<td>81 (49.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165 (100.0%)</td>
<td>165 (100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure VII. The participants’ level of knowledge pre / post program about definition of extravasation  n = 165
Table 7. The participants’ level of knowledge pre / post program about clinical signs of extravasation.  n = 165

<table>
<thead>
<tr>
<th>Level</th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>149(90.3%)</td>
<td>9(5.5%)</td>
<td>-28.850-</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>9(5.5%)</td>
<td>27(16.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>7(4.2%)</td>
<td>129(78.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8. The participants’ level of knowledge pre / post program about pharmacological factors risk for extravasation.  n = 165

<table>
<thead>
<tr>
<th></th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>153(92.7%)</td>
<td>3(1.8%)</td>
<td>-36.583</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>10(6.1%)</td>
<td>43(26.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>2(1.2%)</td>
<td>119(72.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 9. The participants’ level of knowledge pre / post program about antibiotics associated with extravasation.  

n = 165

<table>
<thead>
<tr>
<th>Level</th>
<th>Pre intervention Frequency%</th>
<th>Post intervention Frequency%</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>153(92.7%)</td>
<td>3(1.8%)</td>
<td>-36.583</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>10(6.1%)</td>
<td>43(26.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>2(1.2%)</td>
<td>119(72.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 10. The participants’ level of knowledge pre/post program about IVF and electrolytes solutions associated with extravasation.  

<table>
<thead>
<tr>
<th></th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>137(83.0%)</td>
<td>6(3.6%)</td>
<td>-29.434</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>18(10.9%)</td>
<td>14(8.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>10(6.1%)</td>
<td>145(87.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 11. The participants’ level of knowledge pre / post program about Vasocompressive agents associated with extravasation.  

<table>
<thead>
<tr>
<th></th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>155(93.9%)</td>
<td>12(7.3%)</td>
<td>-27.082-</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>6(3.6%)</td>
<td>36(21.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>4(2.4%)</td>
<td>117(70.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n = 165
Table 12. The participants’ level of knowledge pre / post program about consequences of infiltration and extravasation.  

<table>
<thead>
<tr>
<th></th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency%</td>
<td>Frequency%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>150(90.9%)</td>
<td>7(4.2%)</td>
<td>-32.058</td>
<td>0.001</td>
</tr>
<tr>
<td>Fair</td>
<td>11(6.7%)</td>
<td>30(18.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>4(2.4%)</td>
<td>128(77.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165(100.0%)</td>
<td>165(100.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired Difference</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Std. Error Mean</td>
<td>t</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td>----------------</td>
<td>-----------------</td>
<td>-------</td>
</tr>
<tr>
<td>Pre-program Total knowledge - Post program Total knowledge</td>
<td>-16.16364</td>
<td>3.02891</td>
<td>.23580</td>
<td>-68.548</td>
</tr>
</tbody>
</table>

Table 13. Total knowledge pre/post program by using Paired Samples t Test (n =165)
Table 14. The participants’ level of practice pre / post program about preventive measures of IV infiltration and extravasation based on INS standard of practice. n=165

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre intervention</th>
<th>Post intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not done</td>
<td>Done incorrect</td>
</tr>
<tr>
<td>Select the smallest-gauge</td>
<td>27(16.4%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Avoid area of flexion</td>
<td>130(78.8%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Start from distal to proximal</td>
<td>89(53.9%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Insertion of cannula from first attempt</td>
<td>86(52.1%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Assess cannula function by flushing 0.9% saline</td>
<td>120(72.7%)</td>
<td>33(20.0%)</td>
</tr>
<tr>
<td>Insertion site visible</td>
<td>165(100.0%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Tape not circumferential</td>
<td>165(100.0%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Monitoring site hourly for edema (continuous infusion)</td>
<td>112(67.9%)</td>
<td>49(29.7%)</td>
</tr>
<tr>
<td>Documentation of the catheter insertion</td>
<td>165(100.0%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Dilute vesicant medications appropriately</td>
<td>0(0.0%)</td>
<td>95(57.6%)</td>
</tr>
<tr>
<td>Flushed cannula after infusion</td>
<td>162(98.2%)</td>
<td>0(0.0%)</td>
</tr>
</tbody>
</table>

(P value = 0.001)
Table 15. The participants’ level of practice pre / post program about early detection of IV infiltration and extravasation n=165

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre intervention</th>
<th>Post intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired Difference</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
</tr>
<tr>
<td>Perform TLC hourly: Touch, Look, Compare both</td>
<td>-17.04242-</td>
<td>3.65318</td>
</tr>
<tr>
<td>edema using measuring tape</td>
<td>165(100%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Documentation the grade of infiltration or</td>
<td>165(100%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>extravasation using INS scale</td>
<td>165(100%)</td>
<td>0(0.0%)</td>
</tr>
</tbody>
</table>

(P value = 0.001)

Table 16. Total practice pre/post program by using Paired Samples t Test (n=165)
Table 17. The participants’ level of practice pre/post program about immediate intervention when IV infiltration or extravasation occurs.  

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre intervention</th>
<th>Post intervention</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not done</td>
<td>Done incorrect</td>
<td>Done</td>
</tr>
<tr>
<td>Stop infusion immediately</td>
<td>6(3.6%)</td>
<td>0(0.0%)</td>
<td>159(96.4%)</td>
</tr>
<tr>
<td>Leave the cannula in place and aspirate drug</td>
<td>165(100%)</td>
<td>0(0.0%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Check the patient's pulse and capillary refill time</td>
<td>162(98.2%)</td>
<td>0(0.0%)</td>
<td>3(1.8%)</td>
</tr>
<tr>
<td>Action</td>
<td>Count</td>
<td>Percentage</td>
<td>Count</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>Elevate the limb to minimize swelling</td>
<td>165</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>Use a cold / warm pack on the extravasated area</td>
<td>163</td>
<td>98.8%</td>
<td>0</td>
</tr>
<tr>
<td>Insert new cannula</td>
<td>7</td>
<td>4.2%</td>
<td>0</td>
</tr>
<tr>
<td>Notify physician</td>
<td>126</td>
<td>76.4%</td>
<td>39</td>
</tr>
</tbody>
</table>
5. Discussion

Infiltration and extravagation are complications of intravenous administration therapies involving unintended leakage of solution into the surrounding tissue. Consequences range from local irritation to amputation. Pediatric nurses must be equipped with the knowledge and skills to deal with peripheral intravenous therapy. The study revealed that, most of the participants were females, carrying a Diploma degree in nursing and only a few of the nurses participated in in-service training about intravenous therapy and its complications, compared to study done by Lamsal who found that only (15.3%) participated in in-service education (26). This poor result exploring the need for training.

Regarding the nurses’ level of knowledge and practice about preventive measures of IV infiltration and extravasation, such as site selection. The study revealed significant improvement in knowledge and practice after the implementation of the program (P value 0.001). Pre-program most frequently site selected was antecubital area, most of the participants did not avoid area of flexion, and this site is easily accessible although INS standards recommended avoiding area of flexion which has a higher failure rate (4).

Although the participants pre-program had good level of knowledge that 0.9% saline used frequently for flush cannula, only few of the nurses assessed the function of cannula by flushing 0.9% saline, practice improved post program (P value 0.001). In the current study, 20% of the participants had a poor level of practice pre-program; they flushed peripheral cannula with sterile water which is contraindicated for IV flush (37). Most of the nurses did not know that distilled water for IV flushing cause hemolysis of RBCs. This may be attributed to the fact that participants did not emphasize for updating their knowledge and practice

In the current study only few participants had a good level of knowledge that an insertion site must be visible pre-program, after program (P value 0.002). on the other hand all participants pre-program had a poor level of practice they covered the insertion site with non-transparent plaster. Post program, most of the participants kept the insertion site visible (P value 0.001). Similar to previous study done by Smith a baseline audit of 90 PIV found that 40% of PIV sites were not visible, six months post implementation 95% of sites were visible (40). Transparent plaster enables visual inspection of the cannula site, lead to early detection of infiltration and extravasation. Transparent plaster not available in children's hospitals during the study.
Moreover, when this study was initiated there were no locally written protocols or procedures for guidance to be followed about intravenous access in the children's hospitals.

Concerning performance in insertion a cannula from first attempt practice improved after program significantly (P value 0.001). Insertion of cannula in paediatric required expertise nurse to avoid injuries to vein, this indicates the need of continues training.

Insertion of cannula from distal to proximal improved post the program significantly (P value 0.001). Start from distal saving more proximal veins for future, preprogram most of the participants used antecubital, this indicates that nurses need to follow the standard of practice.

Pre training the participants’ regardless qualifications and years of experience had poor practice, they apply plaster tape circumferential, and they thought this method fix cannula in place. This method has tourniquet effect .This finding supported by an article by Amjad which stated that the circumferential tape had tourniquet effect, tight taping could worsen the effects of an infiltration (62). Practice improved post the program significantly (P value 0.001). Moreover, only a few of the participants preprogram monitored site hourly for signs of edema and discoloration during contentious infusion. If the nurse does not monitor the insertion site; this indicates low quality of care, and late detection of infiltration .Some hospitals had a shortage of staff and some nurses ignore their role. Practice improved post program significantly (P value 0.001). This finding agrees to study done by Lim EYP who showed that 87% compliance on frequent IV site inspection post-implementation (39).

Regarding documentation of the cannula insertion, this study revealed that the entire participants did not document insertion of cannula preprogram, practice improved post program (P value 0.001). The nurses should insist to write what they do through supervision, special in the event of a medico-legal claim.

In the current study, more than half of the participants preprogram had poor practice, they diluted vesicant medications with less amounts than required practice improved after program significantly (P value 0.001). The nurses should notify the pharmacy when using short peripheral cannula so that dilution can be adjusted for administration (62). In Paediatric hospitals, the use of short peripheral cannula is common and the nurse is the one who mixes and dilute medication not pharmacist. This due to absent of standard of practice
Regarding early detection of IV infiltration and extravasation the participants did not compare both extremities, did not measure the size of edema and did not document the grade of infiltration or extravasation using INS scale, practice improved post program significantly (P value 0.001). Most of the participants did not check the cannula site during endorsement; this may be due to shortage of staff and overload of work.

Based on the results, the study illustrated significant improvement of the level of knowledge about the definition and the signs of intravenous infiltration post program (P value 0.001). Comparable to study done by Major and Huey there was a statistically significant difference (P < 0.001) between the nurses’ knowledge pre/post the educational intervention (59). The participants not aware with careful nursing assessment to detect infiltration, and were not confident about their knowledge, because their basic education had not adequately prepared them to provide care for patients with IV infiltration and extravasation.

Based on the results the participants did not aware about IV infiltration scale pre- program. The scale not available in Sudan clinical sitting even at the level of private. The participants, after the program (49.1%) knew the grading scale of infiltration. Although all participants received training on how to evaluate the stage of IV infiltrations, near to half not maintain a sustainability post program. This may be related to their level of qualification, most of the participants with diploma upgrading from auxiliary nursing, this finding indicate the need for continuous education and training.

In the current study, few participants knew definition for extravasations. Level of knowledge improved post program significantly (P value 0.001). This finding comparable a study conducted by Mo’men found that 54% of nurses knew the correct definition for extravasation and infiltration (72). The study revealed that the participants’ knowledge about clinical signs of extravasation improved post program significantly (P value 0.001). Some participants confused with infection and some related these signs to cannulation. In the Sudan majority of children with dark skin or brown complex colour which is difficult to recognize extravasation early, this supported by Treadwell that children and neonates with darker skin are more likely to suffer from extravasation (56).

Regarding the level of knowledge about pharmacological factors contributing to the risk for extravasation. Pre-program some nurses prepare the medication and they did not know that PH or concentration of the drug irritate vein. Knowledge improved significantly post program (P value 0.001).
The study showed that, the participants’ knowledge about antibiotics and solutions associated with extravasation improved significantly post program (P value 0.001). This similar to a study done to describe the incidence of extravasation at a paediatric tertiary care hospital, to identify the agents causing extravasation. A total of 42 patients had documented extravasation. The most common medications involved were fluids for IV administration (43%), potassium chloride (26%), and antibiotics (19%) (75).

Moreover the knowledge of Vasocompressive agents associated with extravasation improved post program significantly (P value 0.001). In the present study Vasocompressive agents knew only by nurses working in intensive care units or high dependency units. This may be the most participants in this study with a Diploma and auxiliary nurses' not received enough education and training about intravenous therapy.

The study revealed that the consequences of IV infiltration and extravasation improved post program significantly (P value 0.001).

The study illustrated that, immediate intervention when IV infiltration or extravasation occurred; most nurses stop the infusion immediately. This best intervention of nurses, practice improved post program not significantly (P value 0.67). Although nurses suspected, further intervention to minimize tissue damage. Internationally, hospitals usually keep track in practice and education for regulatory compliance and delivery of better care.

The current study supported by a study done by Sahar named Peripheral Intravenous Complication of Neonates: Effect of Educational Program for Nurses on Prevention and Management. The findings revealed that there was a highly significant difference (P< 0.001) in the pre and post– intervention program in nurses’ knowledge and practice (79).

Also in the present study the nurses’ practice pre-program was significant (P value 0·001). This finding contradicts a study done by George to study the effectiveness of structured teaching program on knowledge and practices of staff nurses on prevention of intravenous cannula complications. The post-test knowledge found to be highly significant at 0.05 level (P < 0.05), whereas practice score was not significant (P > 0.05). (74)
5.2 Conclusion

The current study concluded that most of the participants had a poor level of knowledge about preventive measures of intravenous infiltration and extravasation pre-program, selection site, visibility of insertion site, definition of extravasation and medication potential to cause extravasation. Knowledge improved post program with significant positive effect on the participants' knowledge.

Most of the participants had poor performance preprogram about the practice of preventive measures of intravenous infiltration and extravasation, start from distal to proximal, dilute vesicant medications appropriately and measuring the stage of infiltration. Post training program practice improved significantly. It was concluded that training programs should be considered as a part of nurses' improvement.

5.2 Recommendations

The study recommended that:

- Standards for infusion therapy and practice.

- Establishing expert cannulation nurse for new and placement, maintenance of vascular access devices, administration of medication and reporting complications.

- Establishment continuous professional education centers in hospitals.

- Further studies in incidence of infiltration and extravasation.

Limitation of the Study

- Use arm manikin not real patient to assess nurses' practice

- The busy schedule of the nurses also makes the collection of data difficult one.
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