Journal of Pediatric Nursing 56 (2021) 13–17

Contents lists available at ScienceDirect

Journal of Pediatric Nursing

journal homepage: www.pediatricnursing.org

Improving Peripheral Intravenous Catheter Care for Children with Cancer Receiving Chemotherapy in Malawi☆

Tadala Mulemba [a,c], Rhahim Bank [a,c], Memory Sabantini [a,c], Virginia Chopi [a,c], Grace Chirwa [a,c], Stuart Mumba [a,c], Mary Chasela [a,c], Selina Lemon [a,c], Marilyn Hockenberry [b,c,*]

[a] Baylor College of Medicine Children's Foundation, Malawi
[b] Baylor College of Medicine, TX, United States of America
[c] Texas Children's Hospital, Global Hematology-Oncology-Pediatric-Excellence (HOPE), Malawi

ARTICLE INFO

Article history:
Received 29 June 2020
Revised 25 September 2020
Accepted 25 September 2020

Keywords:
Peripheral intravenous catheter (PIVC)
Childhood cancer
Chemotherapy
Extravasation

ABSTRACT

Purpose: To change pediatric oncology nursing management of peripheral intravenous catheter (PIVC) insertion and care based on current best evidence.
Design and methods: Practice change strategies were developed, and nurses completed education on proper PIVC insertion, dressing placement, and ongoing PIVC assessment with emphasis on preventing chemotherapy extravasation. Nurses also completed a chemotherapy course as part of their orientation program. The plan for PIVC practice change was based on evidence from published research and established PIVC care guidelines. Pre-assessment data revealed numerous PIVC attempts and a high incidence of extravasation (42%) in children with cancer receiving treatment in Malawi.
Results: Post-assessment data nine months later resulted in a reduced extravasation rate from 42% to 4% using point prevalence assessments. PIVC insertion attempts reduced following education and guideline implementation; 81% of children required more than 3 PIVC insertion attempts before the practice change. Only 1% of PIVC insertions required more than 3 attempts after education and practice change implementation. Nurses completed a 32-item written examination before the chemotherapy course; the mean score was 50/100. Upon completion of the chemotherapy course, nurses obtained a mean score of 97/100 on the written examination.
Conclusions: Using an organized approach to nursing practice change improved PIVC care in children with cancer.
Practice implications: This project provides evidence that nursing practice change strategies can be used in any setting including countries like Malawi with limited resources.

Introduction

In the United States, where center-based chemotherapy administration procedures are established to minimize risk, chemotherapy extravasation still occurs in up to 6% of patients when administered through a peripheral intravenous catheter (PIVC) (Kreidieh, Moukadem, & Saghir, 2016). However, most chemotherapy given in the United States is through a central venous line. In developing countries central venous lines are frequently not available and the only option for chemotherapy administration is the PIVC. Essential to improving childhood cancer cure in underserved countries is the correct administration of chemotherapy; this reinforces the importance of nursing expertise in PIVC insertion and care. Knowledge of chemotherapy administration and the additional risks of PIVC administration of vesicants is key for nurses providing care for children with cancer throughout the world (Ribeiro, Antillon, Pedrosa, & Pui, 2016).

Peripheral intravenous catheter (PIVC) insertion is one of the most common procedures in hospitalized children (Ben Abdelaziz et al., 2017; Marsh, Webster, Mihala, & Rickard, 2015; Ullman et al., 2020). PIVC insertion is frequently challenging in children and insertion attempts requiring 10 or more attempts are reported (Cooke et al., 2018; Kleidon et al., 2017; Ullman et al., 2020). A cross-sectional study conducted in 25 countries evaluated PIVC placements in children. Child caregivers ($n = 712$) reported a 64% insertion failure on the first intravenous attempt; over 23% of children required greater than 4 insertion attempts (Cooke et al., 2018). PIVC complications are numerous and can include pain on insertion, clotting, occlusion, leakage, infiltration, extravasation, phlebitis and infection (Alexandrou et al., 2015, 2018; Ben Abdelaziz et al., 2017; de Lima Jacinto, Avelar, & Pedreira, 2011; Malyon et al., 2014; Simin, Milutinović, Turkulov, & Brkić, 2019; Wallis et al., 2014; Zempsky, 2008). An international study evaluating use of PIVCs ($n = 40,620$) in 51 countries found catheter placement in

☆ Global HOPE Nursing is supported by Bristol Myers Squibb Foundation, Sky High for Kids, The ELMA Foundation, and Celgene.
* Corresponding author at: Texas Children's Hospital, Baylor College of Medicine, 158 Tall Oaks Circle, Hillsborough, NC 27278, United States of America.
E-mail address: marilyn.hockenberry@bcm.edu (M. Hockenberry).

https://doi.org/10.1016/j.pedn.2020.09.019
0882-5963/

non-recommended sites (66%), idle PIVCs (14%), pain on assessment (10%), symptoms of phlebitis (10%) and suboptimal dressings (21%) (Alexandrou et al., 2018). A study evaluating global pediatric PIVC practices in 47 countries (including Africa) found numerous inconsistencies in PIVC care (Ullman et al., 2020). This secondary data analysis of 4206 PIVCs revealed the need for improved catheter placement, consistent PIVC observation and assessment, removal of idol PIVCs, and focus on dressing integrity. Previous studies evaluating PIVC care emphasize the harm associated with inappropriate insertion and care and stressed the importance of standardized PIVC procedures (Alexandrou et al., 2018; O' Grady et al., 2011; Ullman et al., 2020).

PIVC access in children with cancer requires special considerations and chemotherapy administration includes additional safety concerns specific to the possibility of drug extravasation. Extravasation is caused by chemotherapy agents that are classified as vesicants or irritants. Extravasation occurs when there is leakage of a vesicant or irritant into the tissue surrounding the PIVC site that can result in tissue damage and necrosis. Vesicants are categorized as those that increase damage as the agent is spread throughout the tissues (e.g. doxorubicin, daunorubicin) or agents that infiltrate the tissue and become diluted. (e.g. vincristine, vinblastine) (Herring, 2019).

Risk factors associated with chemotherapy extravasation include small or fragile veins, previous multiple venipunctures, poor cannula size and location selection, lack of training of nurses, accidental puncturing the vein upon movement and insecure dressing placement (Herring, 2019; Kreidieh et al., 2016). Risks associated with PIVC chemotherapy administration warrant organized procedures and education programs to improve safety and minimize complications associated with extravasating agents.

In Malawi, all children with cancer receive chemotherapy through PIVCs. This nursing practice change project discusses the implementation of standardized procedures and changes in nursing practice to improve PIVC insertion and care. A focus on PIVC chemotherapy administration procedures was implemented to decrease PIVC insertion attempts, extravasation rates, and standardize PIVC care at the Baylor-Malawi Centre of Excellence at Kamuzu Central Hospital (KCH) in Lilongwe, Malawi.

Methods

This nursing practice change project was implemented at the Baylor-Malawi Pediatric Global Hematology/Oncology Centre of Excellence (Global HOPE) at Kamuzu Central Hospital (KCH) in Lilongwe, Malawi. The Centre is one of three childhood cancer centers supported by the Baylor College of Medicine (BCM) Children's Foundation-Malawi (Baylor-Malawi) and is an indigenous not-for-profit, non-governmental Malawian organization affiliated with the Baylor International Pediatric AIDS Initiative (BIPAI).

Global HOPE in Malawi offers both pediatric in-patient and outpatient services. The clinic sees approximately 100 patients per month; between the ages of 5 months −16 years. Baylor-Malawi employs eight pediatric nurses who care for patients in the inpatient and outpatient settings. Nurses cover nursing care around the clock, seven days a week. No formal education in pediatric oncology nursing was completed and none of the nurses were trained in chemotherapy administration. No established standard procedures for PIVC insertion and chemotherapy administration existed. The establishment of the Global HOPE Nursing program in 2018 led to the development of a formal education program and implementation of standardized nursing procedures for PIVC care and safe chemotherapy administration. The nursing program is coordinated in Malawi by a nurse trainer who is responsible for educating nurses caring for children with cancer. The Global HOPE nursing director is responsible for overall supervision of nurses at all three childhood cancer centers and works with the nurse trainer to develop written nursing education materials and clinical practice standards.

Pre-assessment data collection

This project was not submitted for a research internal review board since PIVC assessment was part of a clinical practice change integrated into the standard procedures for all PIVC care. Prior to implementation of this practice change, no transparent dressings that allowed proper visualization of the PIVC site were available at the site. Vein visualization technology to increase insertion success was not available at the site and an increased number of attempts were required to insert a PIVC on each child. There were no standards for PIVC care, chemotherapy administration, or extravasation prevention.

Prior to implementing the practice change, the number of PIVC insertion attempts for one week was documented for all patients. Point prevalence assessments were used on two separate occasions one month apart, to provide an assessment prior to practice change. The presence of extravasation in children receiving chemotherapy allowed for evaluation of the proportion of the population who had extravasation at two separate time points one month apart. Children who were present in the clinic or hospitalized on two separate days were screened for extravasation. Evidence of extravasation was obtained by direct observation of scarring at the past intravenous sites, parent history of blistering, redness and skin breakdown following chemotherapy administration, and documentation in the medical record. PIVC dressings were assessed on hospitalized patients to determine if they were placed in a similar manner by the nursing staff.

A 32-question written examination that includes 18 questions on chemotherapy administration was used to assess pre and post nursing knowledge. The written examination, part of the evaluation of the Global HOPE nursing education program, was developed by the Global HOPE Nursing Director with content validated by a group of pediatric oncology experts.

Standardizing procedures and education

Standards for PIVC care were developed using published recommendations for best practice based on existing evidence, clinical applicability and economic impact (Table 1). It was extremely important to consider the cost of PIVC care in Malawi where resources are limited. The working group led by the Society of Critical Care Medicine (O-Grady et al., 2011) recommends the following for successful prevention of PIVC infections: staff education and training careful selection of catheters and insertion sites, hand hygiene and aseptic technique, skin preparation, and standardization of the PIVC site dressing. PIVC insertion can be difficult in pediatric patients and when possible, vein visualization technology can increase the rate of insertion success (Cuper et al., 2013; Demir & Inal, 2019; McNeely, Ream, Thrasher, Dziadkowiec, & Callahan, 2018). The importance of the PIVC dressing and securement is emphasized in numerous study findings (Hetzler, Wilson, Hill, & Hollenback, 2011; Hugill, 2016; Kleidon et al., 2017; Kleidon, Cattanach, Mihala, & Ullman, 2019; Watterson et al., 2018). Proper PIVC dressings should protect the skin puncture site from microbial entry, allow for visual inspection of catheter entry site, reduce motion to prevent vascular injury, and maintain the catheter in a central position within the vein. Flushing the PIVC with normal saline is one of the most crucial factors in the prevention of malfunction and essential component for PIVC care (Goossens, 2015). Nursing procedures for continued PIVC care are essential to prevent complications and include flushing before and after medication administration, careful observation of the site to ensure needle insertion visibility and changing the dressing if it becomes loose or soiled. The PIVC is removed for any signs of phlebitis, leaking, or infiltration. All of these principles of PIVC care were included in the standard procedures.

Table 1
Nursing PRACTICE CHANGE EDUCATION PROGRAM CONTENT.

Topic	Module description	Evaluation
PIVC Insertion and Care	Module uses videos to demonstrate the essentials of proper line placement using peripheral catheters in children. A uniquely devised PIV trainer is used to demonstrate PIV insertion. The use of the VeinViewer® is presented with essential aspects of proper IV placement. Proper PIV dressing management is also demonstrated.	Nurses complete a written exam and simulated check-off on PIVC insertion, flushing, connection to IV tubing and dressing securement
Chemotherapy Administration	Module uses presentations to provide an overview of specific agents used to treat childhood cancer, their mechanisms of action and side-effects. Safe administration of extravasating agents and a separate lecture on extravasation is included.	Nurses complete a written exam and simulated check-off on administering chemotherapy including what to do when extravasation occurs

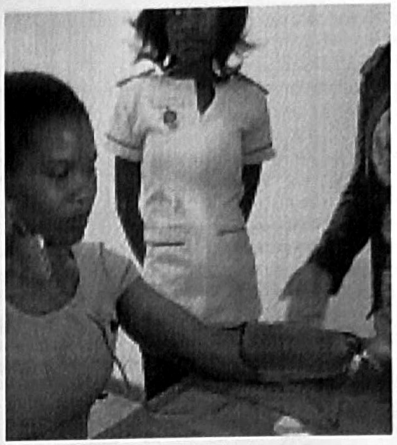

Fig. 1. Nurse using the RediStik PIVC trainer to practice catheter insertion.

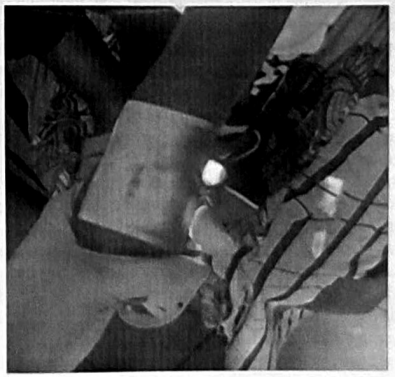

Fig. 2. VeinViewer® showing how veins are easily located.

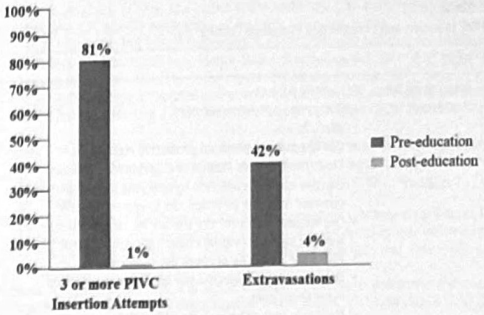

Fig. 3. Changes in PIVC attempts and extravasation rates after education and practice change.

Nurses were educated on proper PIVC insertion following evidence-based standard procedures on the principles of PIVC care established by Global Hope Nursing. PIVC practice trainers and a VeinViewer® were purchased (Christie Medical Holdings, 2020; Texas Children's Hospital, 2020). The RediStik PIVC trainer developed as a low-cost, realistic, durable and wearable simulation tool was used for PIVC insertion practice (Texas Children's Hospital, 2020). The Touch, Look and Compare (TLC) method for assessing the PIVC site was taught (Tofani et al., 2012). This method teaches the nurse how to touch the skin above the PIVC to assess for warmth, look for signs of swelling and redness, and compare the extremity site to the other arm. Skills videos developed to accompany the RediStik PIVC trainer and VeinViewer® were viewed by all nurses (Figure 1, 2, 3 and 4). Each nurse was formally checked off on PIVC insertion, application of the dressing, insertion site assessment, and proper chemotherapy administration to document competence in these essential skills. Nurses completed a chemotherapy course as part of their Global HOPE nursing education. Each nurse completed simulated chemotherapy administration using the PIVC trainer including what to do when extravasation occurs. Specific education content of PIVC insertion and care, chemotherapy administration and extravasation precautions are found in Tables 1-3.

Findings

Pre-assessment data revealed PIVC insertion attempts documented in 266 children seen in the clinic over one week ranged from 0 to >9 with 81% requiring more than 3 insertion attempts. A high incidence of extravasation was found by a prevalence assessment completed on patients seen in the clinic and hospital on one single day: 42% of 24

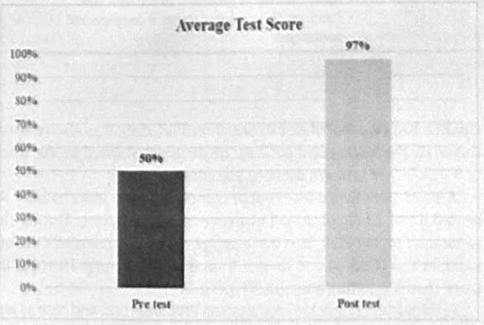

Fig. 4. Changes in chemotherapy exam scores after education and practice change.

Table 2
PIVC Insertion and Care Nursing Procedure Outline.

Topic	Content
Preparation for Insertion	• Identify patient • Gather the necessary supplies • Wash hands • Use appropriate personal protective equipment
PIVC Insertion Procedure	• Clean the site with alcohol or chlorhexidine solution. • Use the antiseptic solution by applying in a circular motion, outward from the insertion site to approx. 2" to 4". • Use friction to "scrub" the site for 30 s in this circular fashion. The key is providing enough friction to "scrub" the site. • Allow the cleansing agent to dry thoroughly. • Do not touch the selected site after skin preparation. • Place tourniquet. • Hold skin taut. (This stabilizes the vein). • Grasp needle or catheter bevel up. • Lightly palpate the vein. • Insert the needle just distal to and along the line of the vein. • Advance needle successfully into vein • Release tourniquet and remove stylet • Flush catheter
PIVC Dressing	• Use sterile tape or sterile surgical strips to secure the hub of the cannula to the skin, so that the device is secure, but the tape does NOT obscure the insertion site. • Consider placing a small piece of cotton wool ball or gauze underneath the hub of the cannula to prevent pressure areas. • Using the semipermeable, occlusive transparent dressing, place the PIV insertion point at the center of the dressing, and lay it against the skin and over the catheter hub. Squeeze the dressing around the catheter hub to secure it to the adhesive and anchor the hub. • Loop the IV extension tubing into a U-shape that points up past the insertion site, leaving the insertion site visible through the transparent occlusive dressing. • Retrieve the second piece of clear tape and lay it across the IV extension tubing. Secure the tape to the skin and occlusive dressing, again making sure to leave the insertion site visible through the transparent dressing. • The insertion site should always be visible for the future evaluation of patency.
PIVC Care	• Document insertion site, date and time. • Saline locked PIVC sites should be flushed before and after medications. • Check PIVC site infusing fluids every 2 h for phlebitis, leaking, infection, infiltration or extravasation using *Touch, Look and Compare Tool*. • Tape and/or dressings should be changed immediately if they become loose, soiled, or damp. Avoid overuse of tape. • Remove PIVC if there is evidence of phlebitis, leaking, infection, infiltration or extravasation.
PIVC Removal	• For PIVC removal, do not use scissors to cut tape. • Remove dressings whilst holding the cannula securely in place (Do not use scissors). • Hold a piece of dry sterile gauze over insertion site but do not apply digital pressure until cannula removed. • Apply pressure for at least 3 to 4 min or until bleeding has stopped. Elevate arm if bleeding persists. • Apply fresh sterile gauze and secure with tape. • Check needle to ensure catheter is complete and undamaged.

children had evidence of an extravasation. PIVC dressings also were observed on the hospitalized patients; no dressings showed needle insertion visibility or uniform dressing placement.

A point prevalence assessment completed nine months later revealed 4% of 23 children had evidence of extravasation. During this same time period PIVC insertion attempts were documented over one week in 153 children and ranged from 0 to 5 with only 1% requiring more than 3 insertion attempts. (Fig. 3).

Eight nurses completed education on PIVC insertion and care as well as chemotherapy administration as part of the Global HOPE nursing education program. The mean score on the pre-assessment written

Table 3
Extravasation Prevention Nursing Procedure Outline.

Topic	Content
Introduction	• Definition of irritant and vesicant • Description of extravasation • Classes of drugs causing extravasation
Extravasation Prevention	• 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 wrist, any site near a joint or in a limb with impaired circulation, and the antecubital area. • Do not administer chemotherapy distal to a recent venipuncture. • New PIVCs should be used when administering vesicants and irritants via peripheral infusion. • After inserting a catheter, check for blood flow and flush with normal saline to check for signs of extravasation. • Monitor the cannula insertion site during each infusion and check regularly for symptoms of extravasation (swelling, redness, pain, sluggish infusion, etc.).
Extravasation During Infusion	• Observe for signs and symptoms of extravasation during the infusion. • Swelling around IV insertion site • Fluid leaking at IV insertion site • Lack of blood return (sometimes a patent IV will not have a blood return; observe closely for the other signs during infusion). • Site cool to touch • Skin may appear blanched • Use ***SLAPP*** for Immediate Management (Herring, 2019) **S** = stop the infusion **L** = leave the needle **A** = aspirate as much as possible **P** = pull the needle **P** = provider notification

examination was 50/100 and upon completion of training nurses obtained a 97/100 on the post-assessment (Fig. 4). All of the nurses (100%) reported the RediStik PIVC trainer helpful - extremely helpful in improving their PIVC insertion skills. Nurses recommended using the RediStik PIVC trainer to teach these skills to new nurses in the future.

Discussion

After implementing this nursing practice change, nurses report less attempts at PIVC insertion sticks in children compared to the number of PIVC attempts before the project. The decrease was dramatic for nurses; following the practice change, most PIVC insertions required less than three attempts. This outcome is significant when considering the population of children with cancer in Malawi. These are young children with other physical problems including malnutrition and advanced cancer, and PIVC insertion is often difficult due to poor vein access.

Chemotherapy education increased understanding of the risks of chemotherapy extravasation and taught appropriate methods for administration of an extravasating agent. During the education program nurses were checked-off on how to administer an extravasating agent and what to do if an extravasation is suspected. The didactic and clinical application activities of the education program resulted in a reduced extravasation rate from 42% to 4%. The extravasation rate in children with PIVCs is now comparable to the incidence found in the United States (Kreidieh et al., 2016). This decrease in extravasation is a tremendous goal reached within less than a year of education and training. Nurses became more confident and comfortable with PIVC care and administration of chemotherapy that can cause extravasation. An important project outcome is that nurses were empowered to become change

agents for quality PIVC care. Since implementation of PIVC practice change, this has become the standard of care for all children receiving chemotherapy for cancer. During orientation new nurses are trained in PIVC care and chemotherapy administration and follow the standardized procedures.

Application to practice

PIVC education plays an important role in all clinical settings, regardless of their location. The PIVC practice change project in Malawi led to a decrease in number of PIVC insertion attempts since nurses were equipped with skills on how to insert and care for PIVCs which was integrated in their daily patient care. New nurses are now trained during orientation.

Conclusion

This project's focus on proper chemotherapy administration through the PIVC was extremely important for children with cancer; extravasation rates decreased. Appropriate chemotherapy administration through a patent PIVC can impact success in treating childhood cancer. Nurses equipped with knowledge and skills in PIVC insertion, care and chemotherapy administration will impact cure of childhood cancer in sub-Saharan Africa.

References

Alexandrou, E., Ray-Barruel, G., Carr, P. J., Frost, S., Inwood, S., Higgins, N., ... Rickard, C. M. (2015). International prevalence of the use of peripheral intravenous catheters. *Journal of Hospital Medicine, 10*(8), 530–533. https://doi.org/10.1002/jhm.2389.

Alexandrou, E., Ray-Barruel, G., Carr, P. J., Frost, S. A., Inwood, S., Higgins, N., ... OMG Study Group (2018). Use of short peripheral intravenous catheters: characteristics, management, and outcomes worldwide. *Journal of Hospital Medicine, 13*(5). https://doi.org/10.12788/jhm.3039 E1-E7.

Ben Abdelaziz, R., Hafsi, H., Hajji, H., Boudabous, H., Ben Chehida, A., Mrabet, A., ... Tebib, N. (2017). Peripheral venous catheter complications in children: predisposing factors in a multicenter prospective cohort study. *Bio Med Central Pediatrics, 17*, 208. https://doi.org/10.1186/s12887-017-0965-y.

Christie Medical Holdings (2020). Vein illumination. https://christiemed.com/vein-illumination/.

Cooke, M., Ullman, A. J., Ray-Barruel, G., Wallis, M., Corley, A., & Rickard, C. M. (2018). Not "just" an intravenous line: Consumer perspectives on peripheral intravenous cannulation (PIVC). An international cross-sectional survey of 25 countries. *PLOS One, 13*(2). https://doi.org/10.1371/journal.pone.0193436 e0193436.

Cuper, N. J., Klaessens, J. H., Jaspers, J. E., de Roode, R., Noordmans, H. J., de Graaff, J. C., & Verdaasdonk, R. M. (2013). The use of near-infrared light for safe and effective visualization of subsurface blood vessels to facilitate blood withdrawal in children. *Medical Engineering & Physics*, 35(4), 433–440. https://doi.org/10.1016/j.medengphy.2012.06.007.

Demir, D., & Inal, S. (2019). Does the use of a vein visualization device for peripheral venous catheter placement increase success rate in pediatric patients? *Pediatric Emergency Care*, 35(7), 474–479. https://doi.org/10.1097/PEC.0000000000001007.

Goossens, G. A. (2015). Flushing and locking of venous catheters: available evidence and evidence deficit. *Nursing Research and Practice, 2015*, 985686. https://doi.org/10.1155/2015/985686.

Herring, R. A. (Ed.). (2019). *The Pediatric Chemotherapy and Biotherapy Curriculum (4th Ed.)*. Chicago, IL: Association of Pediatric Oncology Nurses.

Hetzler, R., Wilson, M., Hill, E. K., & Hollenback, C. (2011). Securing pediatric peripheral i.v. catheters-application of an evidence-based practice model. *Journal of Pediatric Nursing, 26*(2), 143–148. https://doi.org/10.1016/j.pedn.2010.12.008.

Hugill, K. (2016). Is there an optimal way of securing peripheral IV catheters in children? *British Journal of Nursing, 25*(19). https://doi.org/10.12968/bjon.2016.25.19.S20 S20–S21.

Kleidon, T. M., Cattanach, P., Mihala, G., & Ullman, A. J. (2019). Implementation of a paediatric peripheral intravenous catheter care bundle: A quality improvement initiative. *Journal of Paediatrics and Child Health, 55*(10), 1214–1223. https://doi.org/10.1111/jpc.14384.

Kleidon, T. M., Ullman, A. J., Gibson, V., Chaseling, B., Schoutrop, J., Mihala, G., & Rickard, C. M. (2017). A pilot randomized controlled trial of novel dressing and securement techniques in 101 pediatric patients. *Journal of Vascular and Interventional Radiology, 28*(11), 1548–1556. https://doi.org/10.1016/j.jvir.2017.07.012.

Kreidieh, F. Y., Moukadem, H. A., & El Saghir, N. S. (2016). Overview, prevention and management of chemotherapy extravasation. *World Journal of Clinical Oncology, 7*(1), 87–97. https://doi.org/10.5306/wjco.v7.i1.87.

de Lima Jacinto, A. K., Avelar, A. F., & Pedreira, M. L. (2011). Predisposing factors for infiltration in children submitted to peripheral venous catheterization. *Journal of Infusion Nursing, 34*(6). https://doi.org/10.1097/NAN.0b013e3182306491 391–398.

Malyon, L., Ullman, A. J., Phillips, N., Young, J., Kleidon, T., Murfield, J., & Rickard, C. M. (2014). Peripheral intravenous catheter duration and failure in paediatric acute care: A prospective cohort study. *Emergency Medicine Australasia, 26*(6), 602–608. https://doi.org/10.1111/1742-6723.12305.

Marsh, N., Webster, J., Mihala, G., & Rickard, C. M. (2015). Devices and dressings to secure peripheral venous catheters to prevent complications. *The Cochrane Database of Systematic Reviews, 6*. https://doi.org/10.1002/14651858.CD011070.pub2 CD011070.

McNeely, H. L., Ream, T. L., Thrasher, J. M., Dziadkowiec, O., & Callahan, T. J. (2018). Utilization of a biomedical device (VeinViewer®) to assist with peripheral intravenous catheter (PIV) insertion for pediatric nurses. *Journal for Specialists in Pediatric Nursing: JSPN, 23*(2), Article e12208. https://doi.org/10.1111/jspn.12208.

O' Grady, N. P., Alexander, M., Burns, L. A., Dellinger, E. P., Garland, J., Heard, S. O., ... Healthcare Infection Control Practices Advisory Committee (HICPAC) (2011). Guidelines for the prevention of intravascular catheter-related infections. *Clinical Infectious Diseases, 52*(9), e162–e193. https://doi.org/10.1093/cid/cir257.

Ribeiro, R. C., Antillon, F., Pedrosa, F., & Pui, C. H. (2016). Global pediatric oncology: lessons from partnerships between high-income countries and low- to mid-income countries. *Journal of Clinical Oncology, 34*(1), 53–61. https://doi.org/10.1200/JCO.2015.61.9148.

Simin, D., Milutinović, D., Turkulov, V., & Brkić, S. (2019). Incidence, severity and risk factors of peripheral intravenous cannula-induced complications: An observational prospective study. *Journal of Clinical Nursing, 28*(9–10), 1585–1599. https://doi.org/10.1111/jocn.14760.

Texas Children"s Hospital (2020). RediStik Wearable Task Trainer Products. https://www.texaschildrens.org/redistik.

Tofani, B. F., Rineair, S. A., Gosdin, C. H., Pilcher, P. M., McGee, S., Varadarajan, K. R., & Schoettker, P. J. (2012). Quality improvement project to reduce infiltration and extravasation events in a pediatric hospital. *Journal of Pediatric Nursing, 27*(6), 682–689. https://doi.org/10.1016/j.pedn.2012.01.005.

Ullman, A. J., Takashima, M., Kleidon, T., Ray-Barruel, G., Alexandrou, E., & Rickard, C. M. (2020). Global pediatric peripheral intravenous catheter practice and performance: a secondary analysis of 4206 catheters. *Journal of Pediatric Nursing, 50*, e18–e25. https://doi.org/10.1016/j.pedn.2019.09.023.

Wallis, M. C., McGrail, M., Webster, J., Marsh, N., Gowardman, J., Playford, E. G., & Rickard, C. M. (2014). Risk factors for peripheral intravenous catheter failure: a multivariate analysis of data from a randomized controlled trial. *Infection Control and Hospital Epidemiology, 35*(1), 63–68. https://doi.org/10.1086/674398.

Watterson, K., Hauck, M. J., Auker, A., Burns, R., Greider, J., Marlin, M., ... Fenimore, E. (2018). S.T.I.C.K.: A quality improvement pediatric IV infiltration prevention bundle. *Journal of Pediatric Nursing, 41*. https://doi.org/10.1016/j.pedn.2018.01.003 38.41.

Zempsky, W. T. (2008). Optimizing the management of peripheral venous access pain in children: evidence, impact, and implementation. *Pediatrics, 122*(Suppl. 3), S121–S124. https://doi.org/10.1542/peds.2008-1055c.