

# Registered Nurses' Association of Ontario (RNAO) best practice guideline on the assessment and management of vascular access devices

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## Abstract

**Introduction:** Vascular access is the most common invasive procedure performed in health care. This fundamental procedure must be performed in a safe and effective manner. Vascular access devices (VADs) are often the source of infections and other complications, yet there is a lack of clear guidance on VADs for health providers across different settings. A Best Practice Guideline (BPG) was developed by the Registered Nurses' Association of Ontario (RNAO) to provide evidence-based recommendations on the assessment and management of VADs.

**Methods:** RNAO BPGs are based on systematic reviews of the literature following the GRADE approach. Experts on the topic of vascular access were selected to form a panel. Systematic reviews were conducted on six research areas: education, vascular access specialists, blood draws, daily review of peripheral VADs, visualization technologies, and pain management. A search for relevant research studies published in English limited to January 2013 was applied to eight databases. All studies were independently assessed for eligibility and risk of bias by two reviewers based on predetermined inclusion and exclusion criteria. The GRADE approach was used to determine certainty of the evidence.

**Results:** Over 65,000 articles were screened related to the six priority research questions. Of these, 876 full-text publications were examined for relevance, with 174 articles designated to inform nine recommendations in the BPG on the subject areas of: comprehensive health teaching, practical education for health providers, blood draws, daily review of peripheral VADs, visualization technologies, and pain management. In June 2021, the RNAO published the BPG on vascular access, which included the recommendations and other supporting resources.

**Conclusion:** The vascular access BPG provides high quality guidance and updated recommendations, and can serve as a primary resource for health providers assessing and managing VADs.

## Keywords

Guideline, vascular access, nursing, systematic review

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## Introduction

A variety of vascular access devices (VADs) are used in health care, including: peripheral vascular access devices (PVADs), central vascular access devices (CVADs), peripheral arterial catheters (PACs), and phlebotomy devices. Peripheral catheters remain in the periphery with terminal tip below the level of the axillary vein for upper extremity placement, while CVADs are inserted with the terminal tip entering central circulation and advancing

toward the heart.<sup>1</sup> Reliable vascular access is fundamental for safe and effective care.<sup>2</sup> Complications associated with

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**Table 1.** Research questions.

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Research Question #1: Should providing education to persons and their families about their vascular access device be recommended?

Research Question #2: Should practical education for the insertion and management of vascular access devices for health providers be recommended?

Research Question #3: Should vascular access specialist teams be recommended?

Research Question #4: Should blood draws from a vascular access device versus blood draws from venipuncture be recommended?

Research Question #5: Should the daily review of peripheral vascular access devices by health providers be recommended?

Research Question #6: Should the use of visualization technologies (e.g. ultrasound and vein finders) for the insertion of peripheral vascular access devices be recommended?

Research Question #7: Should pain management strategies (including pharmacological and nonpharmacological strategies) during the insertion of a vascular access device be recommended?

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VADs include catheter occlusion, catheter breakage/leakage, bleeding, thrombosis, perforated vessels, phlebitis, infiltration, and extravasation.<sup>3,4</sup> Safe vascular access and management is integral to ensure better outcomes.

The Registered Nurses' Association of Ontario (RNAO) published a best practice guideline (BPG) in June 2021 to provide nurses (i.e. nurse practitioners, registered nurses, registered practical nurses, and nursing students) and other members of the interprofessional team with evidence-based recommendations and resources related to the insertion, assessment and maintenance of VADs in infants, children, and adults.<sup>5</sup> The RNAO guideline team reviewed the two previously published RNAO BPGs on the topic, conducted an environmental scan of existing guidelines, and conducted key informant interviews and discussion groups with key stakeholders. An expert panel was formed, including experts from nursing practice, research, education, and other members of the interprofessional team. Declarations of conflict of interest were made using a standard form by all expert panel members prior to their participation and on an ongoing basis. The new BPG replaces two previous RNAO BPGs: Care and Maintenance to Reduce Vascular Access Complications<sup>6</sup> and Assessment and Device Selection for Vascular Access.<sup>7</sup> The BPG is applicable to nurses, members of the interprofessional team, educators, administrators, executives, policy-makers, researchers, and persons with lived experience in health-service organizations assessing or managing VADs.

## Methods

The BPG was developed following the grading of recommendations, assessment, development, and evaluation (GRADE) approach. GRADE is a system for rating the quality of a body of quantitative evidence in systematic reviews (SR) and grading recommendations in health care.<sup>8</sup> For a more detailed description of the methods, please refer to the full BPG published elsewhere.<sup>5</sup>

The RNAO BPG team and expert panel convened to determine the priority research questions and outcomes. SR questions were developed following the population,

intervention, comparison, and outcomes (PICO) format. See Table 1 for each research question.

## Systematic retrieval of the evidence

The SR was registered in PROSPERO (CRD42019120000). Search strategies were developed by RNAO's BPG team and a health sciences librarian for each research question. A search for relevant research studies published in English limited to January 2013 was applied to the following databases: Cumulative Index to Nursing and Allied Health, Medline, Medline in Process, Cochrane Central, Cochrane Database of Systematic Reviews, Embase, Emcare and Epub ahead of print. Initial searches were conducted in 2018, and updated in 2020. Search dates were limited to the last 5 years from the time of the initial expert panel meeting in order to capture the most up-to-date evidence. Due to the large yield for the research questions on pain management strategies and visualization technologies, an overview of reviews methodology was used (i.e. only SRs and randomized controlled trials (RCTs) were included for research questions 6 and 7). For research question 2 regarding practical education for health providers, the inclusion of SRs and RCTs were prioritized, and non-randomized studies were used to supplement outcomes not reported in the SRs and RCTs.

## Eligibility criteria

Search results were exported into DistillerSR (Evidence Partners, Ottawa, Ontario, Canada) for eligibility screening. All studies were independently assessed for eligibility by two reviewers. Studies were included if they addressed the research question and predetermined outcomes, were published in English and accessible for retrieval. Any study design was eligible for inclusion, excluding expert reports, white papers, consensus documents, discussion papers, case studies, study protocols, dissertations, commentaries, narratives, conference proceedings, and studies without a specific methodology. Full search strategies and selection criteria can be found elsewhere.<sup>5</sup> Disagreements were resolved through consensus.

**Table 2.** GRADE certainty of evidence.

Overall certainty of evidence	Definition
High	We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate	We are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low	Our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low	We have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

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### Data extraction and quality appraisal

Data were extracted independently and in duplicate in standardized Excel sheets (Microsoft Corp, Redmond, Washington). Quality appraisal of individual studies was completed independently and in duplicate by 2 reviewers. Risk of bias was assessed for RCTs using the Cochrane Risk of Bias 2.0 tool,<sup>9</sup> non-randomized studies using the ROBINS-I tool,<sup>10</sup> and SRs using the ROBIS tool.<sup>11</sup> The certainty of the evidence per outcome was determined by two reviewers using the GRADE approach,<sup>8</sup> which includes 5 components: risk of bias, inconsistency, imprecision, indirectness, and publication bias.<sup>8</sup> GRADE categorizes the overall certainty of evidence as high, moderate, low, or very low (see Table 2).<sup>8</sup> An overall certainty of evidence per recommendation was assigned based on these assessments.

### Recommendation formulation

Studies were grouped according to themes based on consensus by two reviewers for each research question and recommendation statements were drafted. For each draft recommendation, GRADE evidence profiles and Evidence-to-Decision (EtD) frameworks were constructed. Two virtual panel meetings were held to determine the direction (i.e. a recommendation for or against an intervention) and the strength (i.e. strong or conditional) of the recommendations. A strong recommendation indicates that the expert panel is confident that the desirable effects of an intervention outweigh its undesirable effects.<sup>8</sup> A conditional recommendation indicates that the desirable effects probably outweigh the undesirable effects, however not all individuals will be best served by the recommended course of action.<sup>8</sup> The final direction and strength of the recommendations were determined by discussion of GRADE considerations, including: benefits and harms; certainty of evidence; values and preferences; and, health equity.<sup>8</sup> A consensus vote of at least 70 percent of panel members determined the final direction and strength of the recommendations.

### Results

Two reviewers screened over 65,000 articles pertaining to the seven research questions. Of these, 876 full-texts were examined for relevance, and 174 articles were included to inform nine recommendations (see Table 3). Details of the included studies can be found in Supplemental File 1. Additional Supplemental Material is published elsewhere.<sup>5</sup>

#### Recommendation 1.1: Education for persons and their families

Nine studies informed this recommendation.<sup>12–20</sup> The evidence focused on comprehensive health teaching for CVADs. Two studies focused on self-management education,<sup>12,13</sup> while seven studies focused on family/caregiver education.<sup>14–20</sup>

Evidence suggests that comprehensive health teaching may reduce complications and hospital re-admission rates.<sup>12–22</sup> However, the evidence is very uncertain. The certainty of evidence was rated as very low due to serious limitations in how individual studies were conducted, serious imprecision related to the small number of events or participants, and inconsistency in how outcomes were measured.

The expert panel determined the recommendation to be strong due to the potential for harm (e.g. complications and hospital readmissions) when health teaching is not provided by health providers. This approach for making a strong recommendation despite very low certainty evidence aligns with the GRADE paradigmatic situations.<sup>23</sup>

#### Recommendation 2.1: Practical education for health providers

Thirty-six studies informed this recommendation.<sup>24–59</sup> Practical education in the evidence varied, including: simulation,<sup>24,27–29,31,32,38,40,43,44,46–48,50–54,56,58</sup> hands-on experience,<sup>25,26,30,33,35–37,39,41,42,45,47,49,55</sup> or individualized mentoring.<sup>34,40</sup>

**Table 3.** Summary of recommendations.

Recommendations	Strength of the recommendation
Recommendation 1.1: The expert panel recommends that health providers provide comprehensive health teaching to persons and their families/caregivers about their vascular access device.	Strong
Recommendation 2.1: The expert panel recommends health-service organizations implement practical education on the insertion and/or management of vascular access devices for health providers.	Strong
Recommendation 3.1: The expert panel suggests that acute care health-service organizations implement vascular access specialists or vascular access specialist teams to support the insertion and management of vascular access devices.	Conditional
Recommendation 4.1: The expert panel suggests health providers perform venipuncture when drawing blood samples to maintain specimen integrity.	Conditional
Recommendation 5.1: The expert panel recommends that acute care health-service organizations implement a multi-component peripheral vascular access device care protocol. This protocol includes a minimum of a daily review by health providers, in collaboration with persons and their families.	Strong
Recommendation 6.1: The expert panel recommends that health providers use ultrasound-guided technique for the insertion of peripheral arterial catheters.	Strong
Recommendation 6.2: The expert panel suggests that health providers use ultrasound-guided technique for the insertion of peripheral vascular access devices in persons with difficult intravenous access.	Conditional
Recommendation 7.1: The expert panel recommends that health providers offer adults non-pharmacological and pharmacological pain management strategies during the insertion of a vascular access device.	Strong
Recommendation 7.2: The expert panel recommends that health providers offer non-pharmacological and pharmacological pain management strategies during the insertion of a vascular access device to infants and children, tailored to their age and developmental stage.	Strong

The evidence suggests that practical education for health providers improves the number of successful attempts of VAD insertions, probably reduces complications, and may improve provider attitude/confidence, although the evidence is uncertain.<sup>24–58</sup> The overall certainty of the evidence was rated low due to serious concerns in how individual studies were conducted, inconsistency in the measurement of the outcomes, and imprecision related to the small number of total events or participants across the studies.

The expert panel voted the recommendation as strong since there were no harms noted in the studies, the education was highly valued by health providers, and all health providers benefited from practical education.

### **Recommendation 3.1: Vascular access specialist teams (VAST)**

Eight studies informed this recommendation.<sup>60–67</sup> Most studies focused on the insertion and management of CVADs, including PICCs,<sup>60–63,67</sup> and three studies focused on PVADs.<sup>64–66</sup> All studies took place in acute care settings; therefore, this recommendation is specific to acute care.

The evidence suggests the implementation of VAST and vascular access specialists (VAS) may reduce complications, and probably improves successful insertion attempts of VADs.<sup>60–67</sup> The certainty of the evidence was rated as low due to serious concerns about imprecision related to the small number of events or participants across

studies, and concerns about how individual studies were conducted.

The expert panel felt the evidence was insufficient to make a strong recommendation. Therefore, the recommendation was determined to be conditional.

### **Recommendation 4.1: Blood draws**

Four studies informed this recommendation.<sup>68–71</sup> The evidence suggests that venipuncture for drawing blood samples may reduce specimen rejection and contamination of blood cultures compared with drawing blood from a VAD.<sup>68,69,71</sup> However, one study also suggests that venipuncture for blood draws may reduce person satisfaction when compared with drawing blood from a VAD.<sup>69</sup> The overall certainty of evidence was rated as very low due to limitations in how individual studies were conducted, inconsistency across study results and a low number of events or participants for some outcomes.

The expert panel noted the potential for additional harms that were not captured in the body of evidence, and blood draws using venipuncture may not be appropriate at all times for all people. Therefore, the recommendation was determined to be conditional.

### **Recommendation 5.1: Daily review of PVADs**

Thirteen studies informed this recommendation.<sup>65,72–83</sup> Studies examined multi-component care protocols which involved PVAD daily review and documentation.<sup>65,72–83</sup>

At a minimum, daily review involved an assessment of signs and symptoms of PVAD complications.<sup>65,72–83</sup> This recommendation is specific to acute care, since all studies took place in acute care settings.

The evidence suggests that multi-component PVAD care protocols may reduce complications.<sup>65,72–83</sup> The certainty of the evidence was rated as low due to serious limitations in how individual studies were conducted.

There was some evidence to suggest that PVAD care protocols would be highly valued by persons and families/caregivers. Conventionally based on GRADE, this recommendation could have been voted conditional since the certainty of the evidence was low; however, based on the balance of benefits and harms, including additional harms not captured in the literature, as well as values and preferences, a strong recommendation was selected by the expert panel.

### **Recommendation 6.1: Visualization technologies—PACs**

Six studies informed this recommendation.<sup>84–89</sup> Evidence suggests that the use of ultrasound-guided technique for the insertion of PACs increases the success rate on first attempt and likely reduces complications.<sup>84–89</sup> The evidence was of moderate certainty due to some limitations in how individual studies were conducted.

The expert panel noted the potential harms of not using ultrasound-guided technique can be severe, including ischemia, hemorrhage, and thrombosis. The expert panel determined the recommendation to be strong.

### **Recommendation 6.2: Visualization technologies—PVADs**

Nine studies informed this recommendation.<sup>90–98</sup> Evidence suggests that the use of ultrasound-guided technique for the insertion of PVADs in persons with difficult intravenous access (DiVA) may increase the success rate on first attempt and decrease complications, and likely increases person satisfaction.<sup>90–92,94–98</sup> However, the certainty of the evidence was very low due to limitations in how individual studies were conducted and inconsistency in the reported results.

The expert panel determined the recommendation to be conditional, since the success of this recommendation would be dependent on individual considerations of the person receiving the PVAD and the expertise of the health provider.

### **Recommendation 7.1: Pain management strategies—adults**

Twenty-six studies informed this recommendation.<sup>99–124</sup> The majority of pharmacological studies focused on topical anesthetics.<sup>99,100,104–108,111</sup> Non-pharmacological interventions included physical and psychological interventions

(e.g. distraction techniques, acupressure, heat, or cold).<sup>100,102,103,109,111–124</sup> Evidence suggests that both pharmacological and non-pharmacological pain management interventions probably decrease pain, fear and anxiety, increase person satisfaction, and may increase comfort.<sup>99–124</sup> The evidence was of moderate certainty due to how individual studies were conducted and inconsistency in the measurement of the outcomes.

The expert panel chose the action word “offer” for this recommendation to highlight that pain management strategies need to be person- and family-centred. The expert panel determined the recommendation to be strong.

### **Recommendation 7.2: Pain management strategies—pediatrics**

Sixty-four studies informed this recommendation.<sup>101,103,113,125–185</sup> The majority of studies examined non-pharmacological interventions<sup>101,103,127–135,137,139–183,186–188</sup> which varied with child/infant age and developmental stage. Various pharmacological interventions were used in the studies.<sup>103,125,126,138,185</sup> Evidence suggests that both pharmacological and non-pharmacological pain management interventions may decrease pain<sup>101,103,125–134,178–185</sup> fear and anxiety,<sup>129,131,133,181–183</sup> and increase comfort,<sup>169</sup> and they probably increase person or parent/guardian satisfaction.<sup>101</sup> The evidence was of low certainty due to some concerns over how individual studies were conducted, inconsistency in the measurement of the outcomes, and variability in the types of procedures examined.

The interventions were highly valued by children and parents/guardians, and the expert panel felt that they aligned with person- and family-centered care principles. Based on the balance of benefits and harms, values and preferences the expert panel determined the recommendation to be strong.

### **Summary of results**

This BPG serves to expand the recommendations in previous editions<sup>6,7</sup> into seven subject areas. Recommendations 5.1, 6.1, and 6.2 speak specifically to PVADs/PACs, and recommendations 1.1, 2.1, 3.1, 4.1, 7.1, and 7.2 encompass both PVADs and CVADs. The evidence was reviewed by the expert panel and resulted in a total of nine recommendations: six strong recommendations and three conditional recommendations. These recommendations serve to provide practical guidance for nurses and other health providers.

### **Discussion**

In reviewing the evidence for this BPG, the RNAO BPG team and the expert panel also identified priority areas for future research. A detailed list of research gaps is outlined in the full BPG.<sup>5</sup> Additionally, the full BPG includes a

workflow algorithm for the order of recommendations in practice.<sup>5</sup>

### **Recommendation 1.1: Education for persons and their families**

Comprehensive health teaching involves a combination of learning experiences designed to improve knowledge and skills related to management of VADs.<sup>12–15</sup> The expert panel deemed the provision of comprehensive health teaching as a strong recommendation because providing persons and their families/caregivers with this teaching is likely beneficial and valued. Provision of such education aligns with principles of person and family-centered care, self-management and autonomy.<sup>5</sup> There are also harms associated with not providing health teaching, including device failure or complications.<sup>5</sup> The Canadian Vascular Access Association (CVAA) infusion therapy guidelines include patient education as a core practice<sup>189</sup> and the Infusion Nurses Society (INS) standards of practice include a standard for patient education that includes topics and teaching strategies.<sup>190</sup>

### **Recommendation 2.1: Practical education for health providers**

Practical education refers to skills practice, supervised insertion, and management of VADs, following a structured teaching format allowing learners repeated, risk-free practice of targeted skills.<sup>5</sup> The expert panel felt practical education provided benefits that can improve outcomes. The literature indicated that education is highly valued by health providers,<sup>37,42,47,52,53,55,56</sup> and may improve the confidence and attitude of the provider.<sup>5</sup> Provision of education aligns with the CVAA guidelines,<sup>189</sup> which outline organizational and health provider responsibilities related to education and competency development and maintenance.<sup>189</sup> The INS standards of practice also have a dedicated standard which recommends the provision of education and skill development for health providers, encouraging a blended learning approach to support learner development.<sup>190</sup>

### **Recommendation 3.1: VAST**

There is a growing body of evidence indicating the use of VAST results in improved outcomes. The recommendation to establish teams for insertion and management of VADs received conditional support related to the low certainty of evidence.<sup>5</sup> A Cochrane report investigating VAST published similar findings due to lack of randomized trials.<sup>191</sup> The evidence reviewed for this recommendation was suggestive of reduced complications by using specially trained health providers.<sup>60–63,65,67</sup> This view of greater safety with VAST was also supported by the Centers for Disease

Control 2011 guidelines.<sup>192</sup> In the CVAA guidelines, a section is dedicated to outlining clinical responsibilities and practices of a VAS service.<sup>189</sup> The expert panel also noted that there is limited evidence on the cost-effectiveness of VAST or VAS, and some organizations may have challenges implementing these services due to cost or organization size.<sup>5</sup>

### **Recommendation 4.1: Blood draws**

The evidence suggests that venipuncture may reduce specimen rejection and contamination compared to drawing blood from VADs.<sup>68,69,71</sup> However, venipuncture for drawing blood samples may reduce person satisfaction when compared to drawing blood from VADs.<sup>69</sup> The certainty of the evidence was very low.<sup>5</sup> The expert panel felt that the potential for additional harm was not captured in the body of evidence, and that venipuncture may not be appropriate in certain circumstances (i.e. young children, people requiring repeated blood work, or older adults with DiVA).<sup>5</sup> For these reasons, the expert panel concluded the strength of the recommendation to be conditional. In addition, health providers must conduct an individualized risk-benefit assessment prior to blood draws from VADs, and adhere to a standardized blood sampling protocol or policy when drawing blood from VADs.<sup>5</sup> Practice guidelines from CVAA, INS, and the World Health Organization provide standards and procedures to support practices when drawing blood from VADs.<sup>189,190,193</sup>

### **Recommendation 5.1: Daily review of PVADs**

Evaluation of PVADs is necessary to identify complications in the early stages and assess whether the device is still needed for therapy. One validated multi-component care protocol well outlined in the literature is the I-Decided IV Assessment and Decision Tool.<sup>194</sup> The protocol points included in the tool are: identification of the PVAD; determining if it is still needed; if the PVAD is functioning properly; if any signs of pain, redness or edema are present; infection prevention disinfection practices for each access point; dressing and securement assessment; person and family education; and, documentation of conclusions or necessary interventions.<sup>194</sup> Using an established tool is found to be effective for training, insertion, and assessment of VADs, to ensure all key areas receive proper attention with adherence to safe practices.<sup>190,195–197</sup> Acute care organizations should consider implementation of a multi-component PVAD care protocol. Use within home and alternative care settings should also be considered, however correct applicability and feasibility of a daily review in settings other than acute care could be difficult to implement systematically. The guideline panel established that there were already high-quality guidelines that provided recommendations

on observation criteria for CVADs, and chose to focus the systematic review on PVADs.

### **Recommendation 6.1: Visualization technologies—PACs**

Insertion of PACs is painful and often requires multiple attempts resulting in trauma to the vessel and surrounding tissues. The use of ultrasound technology allows immediate identification of the target artery and has the potential to guide the needle into the artery with less trauma, and fewer attempts and complications.<sup>198–200</sup> Palpation has been the standard method for selecting an insertion location for PACs. As more evidence is published, improved outcomes utilizing ultrasound-guided PAC insertion demonstrate that the standard for insertion should change. Due to the potential for harm with this procedure, and the moderate certainty of the evidence, the expert panel determined a strong recommendation.

### **Recommendation 6.2: Visualization technologies—PVADs**

Application of ultrasound technology for PVAD insertions is becoming more common for use with persons with DiVA. Ultrasound technology allows the inserter to quickly identify the path of the vein facilitating more successful catheter insertion.<sup>98,190,201</sup> With adequate training, health providers can perform ultrasound-guided PVAD insertions with real-time needle guidance and reduce insertion attempts. The body of evidence is increasing in this area, but currently includes few randomized studies. The current evidence suggests the use of visualization technologies will improve success rates and will likely reduce complications of PVADs.<sup>90–92,94–98</sup> However, the provision of adequate training and availability of ultrasound devices limits effective application. The success of this recommendation would also be dependent on individual considerations and should take into account personal preferences for insertion of PVADs. Considering the evolving nature of this change of practice, and without substantial high certainty evidence, a conditional recommendation was determined.

### **Recommendations 7.1 and 7.2: Pain management strategies—adults, infants, and children**

Despite the low to moderate certainty of the evidence to support non-pharmacological and pharmacological pain management for VAD insertion across the lifespan, the expert panel voted these recommendations as strong due to the benefits outweighing the harms, and the alignment with person- and family-centred care principles.<sup>5</sup> The

support of these recommendations aligns with the CVAA guideline,<sup>189</sup> INS guideline,<sup>190</sup> RNAO Assessment and Management of Pain BPG,<sup>202</sup> and RNAO's Long-term Care Best Practices Toolkit.<sup>203</sup> Pain management interventions may decrease fear, anxiety, pain and increase comfort and person/family satisfaction during the insertion of VADs throughout the lifespan.<sup>5</sup>

### **Limitations**

Due to timelines and feasibility, only seven research questions were asked, which limits the comprehensiveness of the guideline. Future editions of the guideline should consider prioritizing studies conducted in additional areas, such as settings outside of acute care (e.g. home care and long-term care) to provide further evidence to support high-quality and equitable support for persons with VADs. Additionally, new evidence on VADs is becoming available every day. RNAO aims to update the BPGs every 5 years, since published evidence may change the recommendations included in this BPG.

### **Conclusion**

The goal of RNAO's BPGs are to support health providers with evidence-based guidelines for care. This vascular access BPG provides guidance and updated recommendations and serves as a primary resource to guide health providers in assessing and managing VADs.

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### **Declarations**

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## Supplemental material

Supplemental material for this article is available online.

## References

- Hill S and Moureau NL. Tip position. In: Moureau NL (ed.) *Vessel health and preservation: the right approach for vascular access*. Cham: Springer International Publishing, 2019, pp.81–105.
- Simonov M, Pittiruti M, Rickard CM, et al. Navigating venous access: a guide for hospitalists. *J Hosp Med* 2015; 10(7): 471–478.
- Bodenham Chair A, Babu S, Bennett J, et al. Association of Anaesthetists of Great Britain and Ireland: safe vascular access 2016. *Anaesthesia* 2016; 71(5): 573–585.
- Nursing Center. Complications of Peripheral Intravenous Therapy [Internet], <https://www.nursingcenter.com/clinical-resources/nursing-pocket-cards/complications-of-peripheral-i-v-therapy> (2022, accessed 11 April 2023).
- Registered Nurses' Association of Ontario. Vascular Access, Second Edition [Internet], <https://rnao.ca/bpg/guidelines/vascular-access-second-edition> (2021, accessed 30 May 2022).
- Registered Nurses' Association of Ontario. *Care and maintenance to reduce vascular access complications*. Toronto, ON: RNAO; 2005.
- Registered Nurses' Association of Ontario. *Assessment and device selection for vascular access*. Toronto, ON: RNAO; 2004.
- Schunemann HJ, Brozek J, Guyatt G, et al. Handbook for grading the quality of evidence and the strength of recommendations using the GRADE approach. <https://gdt.gradepro.org/app/handbook/handbook.html> (2013, accessed 14 September 2022).
- The Cochrane Collaboration. RoB 2: a revised Cochrane risk-of-bias tool for randomized trials. <https://methods.cochrane.org/bias/resources/rob-2-revised-cochrane-risk-bias-tool-randomized-trials> (2020, accessed 14 September 2022).
- Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* 2016; 355: i4919.
- Whiting P, Savović J, Higgins JP, et al. ROBIS: a new tool to assess risk of bias in systematic reviews was developed. *J Clin Epidemiol* 2016; 69: 225–234.
- Petroulias PL. Use of electronic tablets for patient education on Flushing peripherally inserted central catheters. *J Infus Nurs* 2017; 40(5): 298–304.
- Park JY. Implementing a central venous catheter self-management education program for patients with cancer. *Eur J Oncol Nurs* 2016; 25: 1–8.
- Tan SH, Lee KC, Chao YF, et al. Effects of a family involvement program in patients with central-line insertion. *Clin Nurs Res* 2015; 24(3): 253–268.
- Hicks BL, Brittan MS and Knapp-Clevenger R. Group style central venous catheter education using the GLAD model. *J Pediatr Nurs* 2019; 45: 67–72.
- Lo Vecchio A, Schaffzin JK, Ruberto E, et al. Reduced central line infection rates in children with leukemia following caregiver training: a quality improvement study. *Medicine* 2016; 95(25): e3946.
- Drewe B, Macaluso M, Piper H, et al. Caregiver education reduces the incidence of community-acquired CLABSIs in the pediatric patient with intestinal failure. *Gastroenterol Nurs* 2017; 40(6): 458–462.
- Altounji D, McClanahan R, O'Brien R, et al. Decreasing central line-associated bloodstream infections acquired in the home setting among pediatric oncology patients [Formula: see text]. *J Pediatr Oncol Nurs* 2020; 37(3): 204–211.
- Raybin JL, Tong S, King N, et al. CVAD homecare management: investigating the use of a digital education tool during nurse-delivered instruction to parents for new central lines in children with cancer. *Clin J Oncol Nurs* 2019; 23(3): 295–300.
- Pierik A, Martins DS, Casey L, et al. Use of instructional videos to reduce central venous catheter complications in children with intestinal failure receiving home parenteral nutrition. *Nutr Clin Pract*. 2021; 36(4): 872–876.
- Emery D, Pearson A, Lopez R, et al. Voiceover interactive PowerPoint catheter care education for home parenteral nutrition. *Nutr Clin Pract* 2015; 30(5): 714–719.
- Ma D, Cheng K, Ding P, et al. Self-management of peripherally inserted central catheters after patient discharge via the WeChat smartphone application: a systematic review and meta-analysis. *PLoS One* 2018; 13(8): e0202326.
- Andrews JC, Schünemann HJ, Oxman AD, et al. GRADE guidelines: 15. Going from evidence to recommendation—determinants of a recommendation's direction and strength. *J Clin Epidemiol* 2013; 66(7): 726–735.
- Madenci AL, Solis CV and de Moya MA. Central venous access by trainees: a systematic review and meta-analysis of the use of simulation to improve success rate on patients. *Simul Healthc* 2014; 9(1): 7–14.
- Lindenmaier TJ, Brown J, Ranieri L, et al. The effect of an e-learning module on health sciences students' venipuncture skill development. *Can J Respir Ther* 2018; 54(1): 12–16.
- Keleekai NL, Schuster CA, Murray CL, et al. Improving nurses' peripheral intravenous catheter insertion knowledge, confidence, and skills using a simulation-based blended learning program: a randomized trial. *Simul Healthc* 2016; 11(6): 376–384.
- Peltan ID, Shiga T, Gordon JA, et al. Simulation improves procedural protocol adherence during central venous catheter placement: a randomized controlled trial. *Simul Healthc* 2015; 10(5): 270–276.
- Nakayama Y, Inagaki Y, Nakajima Y, et al. A Practical Training Program for peripheral radial artery catheterization in adult patients: a prospective, randomized controlled trial. *Anesthesiology* 2016; 125(4): 716–723.
- Hebbar KB, Cunningham C, McCracken C, et al. Simulation-based paediatric intensive care unit central venous line maintenance bundle training. *Intensive Crit Care Nurs* 2015; 31(1): 44–50.



30. Oh EJ, Lee JH, Kwon EJ, et al. Simulation-based training using a vessel phantom effectively improved first attempt success and dynamic needle-tip positioning ability for ultrasound-guided radial artery cannulation in real patients: an assessor-blinded randomized controlled study. *PLoS One* 2020; 15(6): e0234567.
31. İsmailoğlu EG, Orkun N, Eşer, et al. Comparison of the effectiveness of the virtual simulator and video-assisted teaching on intravenous catheter insertion skills and self-confidence: a quasi-experimental study. *Nurse Educ Today* 2020; 95: 104596.
32. Akbarzadeh B, Valizadeh L, Ghiyasvandian S, et al. The effects of role play simulation and demonstration on pediatric peripheral venous catheter insertion skill among nursing students: a three group experimental study. *Nurs Midwifery Stud* 2021; 10(1): 1–6.
33. Oliveira L and Lawrence M. Ultrasound-guided peripheral intravenous access program for emergency physicians, nurses, and Corpsmen (Technicians) at a Military Hospital. *Mil Med* 2016; 181(3): 272–276.
34. Ault MJ, Tanabe R and Rosen BT. Peripheral intravenous access using ultrasound guidance: defining the learning curve. *J Assoc Vasc Access* 2015; 20(1): 32–36.
35. Grudziak J, Herndon B, Dancel RD, et al. Standardized, interdepartmental, simulation-based central line insertion course closes an educational gap and improves intern comfort with the procedure. *Am Surg* 2017; 83(6): 536–540.
36. Jagneaux T, Caffery TS, Musso MW, et al. Simulation-based education enhances patient safety behaviors during central venous catheter placement. *J Patient Saf* 2021; 17: 425–429.
37. Thomas SM, Burch W, Kuehnle SE, et al. Simulation training for pediatric residents on central venous catheter placement: a pilot study. *Pediatr Crit Care Med* 2013; 14(9): e416–e423.
38. Toy S, McKay RS, Walker JL, et al. Using learner-centered, simulation-based training to improve medical students' procedural skills. *J Med Educ Curric Dev* 2017; 4: 2382120516684829.
39. Barsuk JH, Cohen ER, Mikolajczak A, et al. Simulation-based mastery learning improves central line maintenance skills of ICU nurses. *J Nurs Adm* 2015; 45(10): 511–517.
40. Scholtz AK, Monachino AM, Nishisaki A, et al. Central venous catheter dress rehearsals: translating simulation training to patient care and outcomes. *Simul Healthc* 2013; 8(5): 341–349.
41. Hernández-Padilla JM, Granero-Molina J, Márquez-Hernández VV, et al. Effects of a simulation-based workshop on nursing students' competence in arterial puncture. *Acta Paul Enferm* 2016; 29(6): 678–685.
42. Ballard HA, Tsao M, Robles A, et al. Use of a simulation-based mastery learning curriculum to improve ultrasound-guided vascular access skills of pediatric anesthesiologists. *Paediatr Anaesth* 2020; 30(11): 1204–1210.
43. Balachander B, Rajesh D, Pinto BV, et al. Simulation training to improve aseptic non-touch technique and success during intravenous cannulation-effect on hospital-acquired blood stream infection and knowledge retention after 6 months: the snowball effect theory. *J Vasc Access* 2020; 22(3): 353–358.
44. Wagner M, Hauser K, Cardona F, et al. Implementation and evaluation of training for ultrasound-guided vascular access to small vessels using a low-cost cadaver model. *Pediatr Crit Care Med* 2018; 19(11): E611–E617.
45. Sanchez Novas D, Domenech G, Belitzky NG, et al. Simulation-based training for early procedural skills acquisition in new anesthesia trainees: a prospective observational study. *Adv Simul* 2020; 5: 19.
46. Hassanein SMA, Tantawi HR, Sadek BN, et al. Impact of structured simulation-based and on-job training program on nurses' competency in pediatric peripheral intravenous cannulation: children's hospital experience. *Nurse Educ Today* 2021; 98: 104776.
47. Amick AE, Feinsmith SE, Davis EM, et al. Simulation-based mastery learning improves ultrasound-guided peripheral intravenous catheter insertion skills of practicing nurses. *Simul Healthc* 2022; 17: 7–14.
48. Valizadeh L, Amini A, Fathi-Azar E, et al. The effect of simulation teaching on baccalaureate nursing students' self-confidence related to peripheral venous catheterization in children: a randomized trial. *J Caring Sci* 2013; 2(2): 157–164.
49. Bayci AW, Mangla J, Jenkins CS, et al. Novel Educational Module for subclavian central venous catheter insertion using real-time ultrasound guidance. *J Surg Educ* 2015; 72(6): 1217–1223.
50. Abu Sharour L, Subih M, Yehia D, et al. Teaching module for improving oncology nurses' knowledge and self-confidence about central line catheters caring, complications, and application: a pretest-posttest quasi-experimental design. *J Vasc Nurs* 2018; 36(4): 203–207.
51. Jones GF, Forsyth K, Jenewein CG, et al. Research residents' perceptions of skill decay: effects of repeated skills assessments and scenario difficulty. *Am J Surg* 2017; 213(4): 631–636.
52. Kelly LJ, Green A and Hainey K. Implementing a new teaching and learning strategy for CVAD care. *Br J Nurs* 2015; 24: S4–S12.
53. Archer-Jones A, Sweeny A, Schults JA, et al. Evaluating an ultrasound-guided peripheral intravenous cannulation training program for emergency clinicians: an Australian perspective. *Australas Emerg Care* 2020; 23(3): 151–156.
54. Goodfriend L, Kennedy S, Hein A, et al. Implementation of a vascular access experience program to train unit-based vascular access champions. *J Infus Nurs* 2020; 43(4): 193–199.
55. Spencer TR and Bardin-Spencer AJ. Pre- and post-review of a standardized ultrasound-guided central venous catheterization curriculum evaluating procedural skills acquisition and clinician confidence. *J Vasc Access* 2020; 21(4): 440–448.
56. AlShammari A, Inayah A, Afsar NA, et al. Evaluation of effectiveness of a paediatric simulation course in procedural skills for paediatric residents - a pilot study. *J Pak Med Assoc* 2018; 68(2): 240–246.
57. Sattler LA, Schuety C, Nau M, et al. Simulation-based medical education improves procedural confidence in core invasive procedures for military internal medicine residents. *Cureus* 2020; 12(12): e11998.
58. Purran A, Weller G and Kerr C. Evaluation of a PICC care training programme. *Nurs Stand* 2016; 30(20): 45–50.

59. Hanauer LPT, Comerlato PH, Papke A, et al. Reducing central vein catheterization complications with a focused educational program: a retrospective cohort study. *Sci Rep* 2020; 10(1): 17530.
60. Johnson D, Snyder T, Strader D, et al. Positive influence of a dedicated vascular access team in an acute care hospital. *J Assoc Vasc Access* 2017; 22(1): 35–37.
61. Pitts S. Retrospective analysis of a pediatric vascular access program and clinical outcomes. *J Assoc Vasc Access* 2013; 18(2): 114–120.
62. Savage TJ, Lynch AD and Oddera SE. Implementation of a vascular access team to reduce central line usage and prevent central line-associated bloodstream infections. *J Infus Nurs* 2019; 42(4): 193–196.
63. McDiarmid S, Scrivens N, Carrier M, et al. Outcomes in a nurse-led peripherally inserted central catheter program: a retrospective cohort study. *CMAJ Open* 2017; 5(3): E535–E539.
64. Marsh N, Webster J, Larsen E, et al. Expert versus generalist inserters for peripheral intravenous catheter insertion: a pilot randomised controlled trial. *Trials* 2018; 19(1): 564.
65. Steere L, Ficara C, Davis M, et al. Reaching one peripheral intravenous catheter (PIVC) per patient visit with lean multimodal strategy: the piv5rights™ bundle. *J Assoc Vasc Access* 2019; 24(3): 31–43.
66. Hartman JH, Bena JF, Morrison SL, et al. Effect of adding a pediatric vascular access team component to a pediatric peripheral vascular access algorithm. *J Pediatr Healthc* 2020; 34(1): 4–9.
67. Levit O, Shabanova V and Bizzarro M. Impact of a dedicated nursing team on central line-related complications in neonatal intensive care unit. *J Matern Fetal Neonatal Med* 2020; 33(15): 2618–2622.
68. Coventry LL, Jacob AM, Davies HT, et al. Drawing blood from peripheral intravenous cannula compared with venepuncture: a systematic review and meta-analysis. *J Adv Nurs* 2019; 75(11): 2313–2339.
69. Twibell KR, Hofstetter P, Siela D, et al. A comparative study of blood sampling from venipuncture and short peripheral catheters in pediatric inpatients. *J Infus Nurs* 2019; 42(5): 237–247.
70. Mulloy DF, Lee SM, Gregas M, et al. Effect of peripheral IV based blood collection on catheter dwell time, blood collection, and patient response. *Appl Nurs Res* 2018; 40: 76–79.
71. Zhang Y, Zhang S, Chen J, et al. Blood sampling from peripherally inserted central catheter is effective and safe for patients with head and neck cancers. *J Vasc Access* 2020; 22(3): 424–431.
72. Sriupayo A, Inta N, Boonkongrat S, et al. Effectiveness of peripheral vascular catheter care bundle in the pediatric nursing service, Chiang Mai university hospital, Thailand. *Chiang Mai Med J* 2014; 53(2): 63–73.
73. Watterson K, Hauck MJ, Auken A, et al. S.T.I.C.K.: a quality improvement pediatric IV infiltration prevention bundle. *J Pediatr Nurs* 2018; 41: 38–41.
74. Rhodes D, Cheng AC, McLellan S, et al. Reducing *Staphylococcus aureus* bloodstream infections associated with peripheral intravenous cannulae: successful implementation of a care bundle at a large Australian health service. *J Hosp Infect* 2016; 94(1): 86–91.
75. Wilder KA, Kuehn SC and Moore JE. Peripheral intravenous and central catheter algorithm: a proactive quality initiative. *Adv Neonatal Care* 2014; 14(6): E3–E7.
76. Mestre G, Berbel C, Tortajada P, et al. Successful multifaceted intervention aimed to reduce short peripheral venous catheter-related adverse events: a quasiexperimental cohort study. *Am J Infect Control* 2013; 41(6): 520–526.
77. Saliba P, Hornero A, Cuervo G, et al. Interventions to decrease short-term peripheral venous catheter-related bloodstream infections: impact on incidence and mortality. *J Hosp Infect* 2018; 100(3): e178–e186.
78. Park SM, Jeong IS, Kim KL, et al. The effect of intravenous infiltration management program for hospitalized children. *J Pediatr Nurs* 2016; 31(2): 172–178.
79. Kleidon TM, Cattanaach P, Mihala G, et al. Implementation of a paediatric peripheral intravenous catheter care bundle: a quality improvement initiative. *J Pediatr Child Health* 2019; 55(10): 1214–1223.
80. Garcia-Gasalla M, Arrizabalaga-Asenjo M, Collado-Giner C, et al. Results of a multi-faceted educational intervention to prevent peripheral venous catheter-associated bloodstream infections. *J Hosp Infect* 2019; 102(4): 449–453.
81. Maier D. To replace or not to replace? Replacing short peripheral catheters based on clinical indication. *J Infus Nurs* 2019; 42(3): 143–148.
82. Tasdelen Y and Caglar S. Effect of intravenous infiltration management program on peripheral intravenous catheter success and infiltration in hospitalized infants. *J Nurs Care Qual* 2020; 36(3): E44–E49.
83. Gunasundram S, Tan M, Lim KZH, et al. Reducing the incidence of phlebitis in medical adult inpatients with peripheral venous catheter care bundle: a best practice implementation project. *JBI Evid Implement* 2021; 19(1): 68–83.
84. Zhao W, Peng H, Li H, et al. Effects of ultrasound-guided techniques for radial arterial catheterization: a meta-analysis of randomized controlled trials. *Am J Emerg Med* 2021; 46: 1–9.
85. Liu L, Tan Y, Li S, et al. Modified dynamic needle tip positioning” short-axis, out-of-plane, ultrasound-guided radial artery cannulation in neonates: a randomized controlled trial. *Anesth Analg* 2019; 129(1): 178–183.
86. Gibbons R, Zanaboni A, Saravitz S, et al. Ultrasound guidance versus landmark-guided palpation for radial arterial line placement by novice emergency medicine interns: a randomized controlled trial. *J Emerg Med* 2020; 59(6): 911–917.
87. Wang J, Lai Z, Weng X, et al. Modified long-axis in-plane ultrasound technique versus conventional palpation technique for radial arterial cannulation: a prospective randomized controlled trial. *Medicine* 2020; 99(2): e18747.
88. Wilson C, Rose D, Kelen G, et al. Comparison of ultrasound-guided vs traditional arterial cannulation by emergency medicine residents. *West J Emerg Med* 2020; 21(2): 353–358.

89. Yu Y, Lu X, Fang W, et al. Ultrasound-guided artery cannulation technique versus palpation technique in adult patients in pre-anesthesia room: a randomized controlled trial. *Med Sci Monit* 2019; 25: 7306–7311.
90. Heinrichs J, Fritze Z, Vandermeer B, et al. Ultrasonographically guided peripheral intravenous cannulation of children and adults: a systematic review and meta-analysis. *Ann Emerg Med* 2013; 61(4): 444–454.e1.
91. Bridey C, Thilly N, Lefevre T, et al. Ultrasound-guided versus landmark approach for peripheral intravenous access by critical care nurses: a randomised controlled study. *BMJ Open* 2018; 8(6): e020220.
92. Gopalasingam N, Obad DS, Kristensen BS, et al. Ultrasound-guidance outperforms the palpation technique for peripheral venous catheterisation in anaesthetised toddlers: a randomised study. *Acta Anaesthesiol Scand* 2017; 61: 601–608.
93. Avelar AF, Peterlini MA and da Luz Gonçalves Pedreira M. Ultrasonography-guided peripheral intravenous access in children: a randomized controlled trial. *J Infus Nurs* 2015; 38(5): 320–327.
94. Vinograd AM, Chen AE, Woodford AL, et al. Ultrasonographic guidance to improve first-attempt success in children with predicted difficult intravenous access in the emergency department: a randomized controlled trial. *Ann Emerg Med* 2019; 74(1): 19–27.
95. McCarthy ML, Shokoohi H, Boniface KS, et al. Ultrasonography versus landmark for peripheral intravenous cannulation: a randomized controlled trial. *Ann Emerg Med* 2016; 68(1): 10–18.
96. İsmailoğlu EG, Zaybak A, Akarca FK, et al. The effect of the use of ultrasound in the success of peripheral venous catheterisation. *Int Emerg Nurs* 2015; 23(2): 89–93.
97. Bahl A, Pandurangadu AV, Tucker J, et al. A randomized controlled trial assessing the use of ultrasound for nurse-performed IV placement in difficult access ED patients. *Am J Emerg Med* 2016; 34(10): 1950–1954.
98. van Loon FHJ, Buise MP, Claassen JJF, et al. Comparison of ultrasound guidance with palpation and direct visualisation for peripheral vein cannulation in adult patients: a systematic review and meta-analysis. *Br J Anaesth* 2018; 121(2): 358–366.
99. Bond M, Crathorne L, Peters J, et al. First do no harm: pain relief for the peripheral venous cannulation of adults, a systematic review and network meta-analysis. *BMC Anesthesiol* 2016; 16(1): 81.
100. Vallejo de la Hoz G, Reglero García L, Fernández Aedo I, et al. Alternatives to subcutaneous injection of aminoamide or amino-ester anesthetics before arterial puncture for blood gas analysis: a systematic review. *Emergencias* 2019; 31(2): 115–122.
101. Zhu Y, Peng X, Wang S, et al. Vapocoolant spray versus placebo spray/no treatment for reducing pain from intravenous cannulation: a meta-analysis of randomized controlled trials. *Am J Emerg Med* 2018; 36(11): 2085–2092.
102. Boerner KE, Birnie KA, Chambers CT, et al. Simple psychological interventions for reducing pain from common needle procedures in adults: systematic review of randomized and quasi-randomized controlled trials. *Clin J Pain* 2015; 31(10 Suppl): S90–S98.
103. Hall LM, Ediriweera Y, Banks J, et al. Cooling to reduce the pain associated with vaccination: a systematic review. *Vaccine* 2020; 38(51): 8082–8089.
104. Salar A, Kiani F, Navidian A, et al. A comparative study on the effect of EMLA cream and diclofenac gel on pain caused by needle port placement in patients under chemotherapy: a clinical trial. *Med-Surg Nurs J* 2018; 7(1): e79613.
105. Yin L and Jiang S. Evaluation of EMLA cream for relieving pain during needle insertion on totally implantable venous access device. *J Vasc Access* 2018; 19(6): 634–638.
106. Babaicasl F, Yarandi HN, Saeidzadeh S, et al. Comparison of EMLA and diclofenac on reduction of pain and phlebitis caused by peripheral IV catheter: a randomized-controlled trial study. *Home Healthc Now* 2019; 37(1): 17–22.
107. Kumar S, Sanjeev O, Agarwal A, et al. Double blind randomized control trial to evaluate the efficacy of ketoprofen patch to attenuate pain during venous cannulation. *Korean J Pain* 2018; 31(1): 39–42.
108. Datema J, Veldhuis J and Bekhof J. Lidocaine spray as a local analgesic for intravenous cannulation: a randomized clinical trial. *Eur J Emerg Med* 2019; 26(1): 24–28.
109. Zempsky WT, Schmitz ML and Meyer JM. Safety and efficacy of needle-free powder lidocaine delivery system in adult patients undergoing venipuncture or peripheral venous cannulation: a randomized, double-blind, placebo-controlled trial. *Clin J Pain* 2016; 32(3): 211–217.
110. Samantaray A and Rao MH. Effects of fentanyl on procedural pain and discomfort associated with central venous catheter insertion: a prospective, randomized, double-blind, placebo controlled trial. *Indian J Crit Care Med* 2014; 18(7): 421–426.
111. Pagnucci N, Pagliaro S, Maccheroni C, et al. Reducing pain during emergency arterial sampling using three anesthetic methods: a randomized controlled clinical trial. *J Emerg Med* 2020; 58(6): 857–863.
112. Yılmaz D and Güneş ÜY. The effect on pain of three different nonpharmacological methods in peripheral intravenous catheterisation in adults. *J Clin Nurs* 2018; 27(5–6): 1073–1080.
113. Redfern RE, Micham J, Seegert S, et al. Influencing vaccinations: a buzzy approach to ease the discomfort of a needle stick—a prospective, randomized controlled trial. *Pain Manag Nurs* 2019; 20(2): 164–169.
114. Yılmaz D, Heper Y and Gözler L. Effect of the use of Buzzy® during phlebotomy on pain and individual satisfaction in blood donors. *Pain Manag Nurs* 2017; 18(4): 260–267.
115. Şahin M and Eşer. Effect of the Buzzy application on pain and injection satisfaction in adult patients receiving intramuscular injections. *Pain Manag Nurs* 2018; 19(6): 645–651.
116. Jisha K, Latha S and Joseph G. A comparative study on impact of dry versus moist heat application on feasibility of peripheral intravenous cannulation among the patients of a selected hospital at Mangalore. *J Health Allied Sci NU* 2017; 7(3): 021–024.
117. Hosseinabadi R, Biranvand S, Pourmia Y, et al. The effect of acupressure on pain and anxiety caused by venipuncture. *J Infus Nurs* 2015; 38(6): 397–405.

118. Korkut S, Karadag S and Dogan Z. The effectiveness of local hot and cold applications on peripheral intravenous catheterization: a randomized controlled trial. *J Perianesth Nurs* 2020; 35(6): 597–602.
119. Pakiş Çetin S and Çevik K. Effects of vibration and cold application on pain and anxiety during intravenous catheterization. *J Perianesth Nurs* 2019; 34(4): 701–709.
120. Basak T, Duman S and Demirtas A. Distraction-based relief of pain associated with peripheral intravenous catheterisation in adults: a randomised controlled trial. *J Clin Nurs* 2020; 29(5–6): 770–777.
121. Fusco N, Bernard F, Roelants F, et al. Hypnosis and communication reduce pain and anxiety in peripheral intravenous cannulation: effect of language and confusion on pain during peripheral intravenous catheterization (KTHYPE), a multicentre randomised trial. *Br J Anaesth* 2020; 124(3): 292–298.
122. Yayla EM and Ozdemir L. Effect of inhalation aromatherapy on procedural pain and anxiety after needle insertion into an implantable central venous port catheter: a quasi-randomized controlled pilot study. *Cancer Nurs* 2019; 42(1): 35–41.
123. Akbari F, Rezaei M and Khatony A. Effect of peppermint essence on the pain and anxiety caused by intravenous catheterization in cardiac patients: a randomized controlled trial. *J Pain Res* 2019; 12: 2933–2939.
124. Haynes JM. Randomized controlled trial of cryoanalgesia (ice bag) to reduce pain associated with arterial puncture. *Respir Care* 2015; 60(1): 1–5.
125. Sridharan K and Sivaramakrishnan G. Pharmacological interventions for reducing pain related to immunization or intramuscular injection in children: a mixed treatment comparison network meta-analysis of randomized controlled clinical trials. *J Child Health Care* 2018; 22(3): 393–405.
126. Shahid S, Florez ID and Mbuagbaw L. Efficacy and safety of EMLA cream for pain control due to venipuncture in infants: a meta-analysis. *Pediatrics* 2019; 143(1): e20181173.
127. Kassab M, Foster JP, Foureur M, et al. Sweet-tasting solutions for needle-related procedural pain in infants one month to one year of age. *Cochrane Database Syst Rev* 2012; 12(12): CD008411.
128. Harrison D, Reszel J, Bueno M, et al. Breastfeeding for procedural pain in infants beyond the neonatal period. *Cochrane Database Syst Rev* 2016; 10(10): CD011248.
129. Taddio A, Shah V, McMurtry CM, et al. Procedural and physical interventions for vaccine injections: systematic review of randomized controlled trials and quasi-randomized controlled trials. *Clin J Pain* 2015; 31(10 Suppl): S20–S37.
130. Harrison D, Yamada J, AdamsWebber T, et al. Sweet tasting solutions for reduction of needle-related procedural pain in children aged one to 16 years. *Cochrane Database Syst Rev* 2015; 5(10): CD008408.
131. Birnie KA, Noel M, Chambers CT, et al. Psychological interventions for needle-related procedural pain and distress in children and adolescents. *Cochrane Database Syst Rev* 2018; 10(10): CD005179.
132. Pillai Riddell R, Taddio A, McMurtry CM, et al. Psychological Interventions for vaccine injections in young children 0 to 3 years: systematic review of randomized controlled trials and quasi-randomized controlled trials. *Clin J Pain* 2015; 31(Supplement 10): S64–S71.
133. Ueki S, Yamagami Y and Makimoto K. Effectiveness of vibratory stimulation on needle-related procedural pain in children: a systematic review. *JBI Database System Rev Implement Rep* 2019; 17(7): 1428–1463.
134. Zhang S, Su F, Li J, et al. The analgesic effects of maternal milk odor on newborns: a meta-analysis. *Breastfeed Med* 2018; 13(5): 327–334.
135. Küçük Alemdar D and Yaman Aktaş Y. The use of the buzzy, Jet lidokaine, bubble-blowing and aromatherapy for reducing pediatric pain, stress and fear associated with phlebotomy. *J Pediatr Nurs* 2019; 45: e64–e72.
136. Pour PS, Ameri GF, Kazemi M, et al. Comparison of effects of local anesthesia and two-point acupressure on the severity of venipuncture pain among hospitalized 6-12-year-old children. *J Acupunct Meridian Stud* 2017; 10(3): 187–192.
137. Taddio A, Riddell RP, Ipp M, et al. Relative effectiveness of additive pain interventions during vaccination in infants. *CMAJ* 2017; 189(6): E227–E234.
138. Marseglia L, Manti S, D’Angelo G, et al. Potential use of melatonin in procedural anxiety and pain in children undergoing blood withdrawal. *J Biol Regul Homeost Agents* 2015; 29(2): 509–514.
139. Sri Rahyanti NM, Nurhaeni N and Wanda D. Could a certain sitting position reduce the pain experienced by a child? The benefits of parental holding and an upright position. *Compr Child Adolesc Nurs* 2017; 40(sup1): 8–13.
140. Binay Ş, Bilsin E, Gerçeker GÖ, et al. Comparison of the effectiveness of two different methods of decreasing pain during phlebotomy in children: a randomized controlled trial. *J Perianesth Nurs* 2019; 34: 749–756.
141. Bergomi P, Scudeller L, Pintaldi S, et al. Efficacy of non-pharmacological methods of pain management in children undergoing venipuncture in a pediatric outpatient clinic: a randomized controlled trial of audiovisual distraction and external cold and vibration. *J Pediatr Nurs* 2018; 42: e66–e72.
142. Lee VY, Booy R, Skinner R, et al. The effect of exercise on vaccine-related pain, anxiety and fear during HPV vaccinations in adolescents. *Vaccine* 2018; 36(23): 3254–3259.
143. Canbulat Şahiner N, İnal S and Sevim Akbay A. The effect of combined stimulation of external cold and vibration during immunization on pain and anxiety levels in children. *J Perianesth Nurs* 2015; 30(3): 228–235.
144. Zhu J, Hong-Gu H, Zhou X, et al. Pain relief effect of breast feeding and music therapy during heel lance for healthy-term neonates in China: a randomized controlled trial. *Midwifery* 2015; 31(3): 365–372.
145. Dabas P. Effectiveness of distraction techniques on pain intensity during immunization among infants. *Int J Nurs Educ* 2019; 11(1): 5–9.
146. Tunç-Tuna P and Açıkgöz A. The effect of preintervention preparation on pain and anxiety related to peripheral

- cannulation procedures in children. *Pain Manag Nurs* 2015; 16(6): 846–854.
147. Vagnoli L, Caprilli S, Vernucci C, et al. Can presence of a dog reduce pain and distress in children during venipuncture? *Pain Manag Nurs* 2015; 16(2): 89–95.
  148. Inan G and Inal S. The impact of 3 different distraction techniques on the pain and anxiety levels of children during venipuncture: a clinical trial. *Clin J Pain* 2019; 35(2): 140–147.
  149. Gold JI and Mahrer NE. Is virtual reality ready for prime time in the medical space? A randomized control trial of pediatric virtual reality for acute procedural pain management. *J Pediatr Psychol* 2018; 43(3): 266–275.
  150. Suhrabi Z, Taghinejad H, Valian K, et al. A comparative study on the efficacy of glucose and sucrose on the vaccination pain: a randomized controlled clinical trial. *J Clin Diagn Res* 2014; 8(10): c01–c03.
  151. Bos-Veneman NGP, Otter M and Reijneveld SA. Using feeding to reduce pain during vaccination of formula-fed infants: a randomised controlled trial. *Arch Dis Child* 2018; 103(12): 1132–1137.
  152. Hatami Bavarsad Z, Hemati K, Sayehmiri K, et al. Effects of breast milk on pain severity during muscular injection of hepatitis B vaccine in neonates in a teaching hospital in Iran. *Arch Pediatr* 2018; 25(6): 365–370.
  153. Karaca Ciftci E, Kardas Ozdemir F and Aydın D. Effect of flick application on pain level and duration of crying during infant vaccination. *Ital J Pediatr* 2016; 42: 8–6.
  154. Gad RF, Dowling DA, Abusaad FE, et al. Oral sucrose versus breastfeeding in managing infants' immunization-related pain: a randomized controlled trial. *MCN Am J Matern Child Nurs* 2019; 44(2): 108–114.
  155. Modarres M, Jazayeri A, Rahnama P, et al. Breastfeeding and pain relief in full-term neonates during immunization injections: a clinical randomized trial. *BMC Anesthesiol* 2013; 13(1): 22.
  156. Gouin S, Gaucher N, Lebel D, et al. A randomized double-blind trial comparing the effect on pain of an oral sucrose solution vs. placebo in children 1 to 3 months old undergoing simple venipuncture. *J Emerg Med* 2018; 54(1): 33–39.
  157. Erkut Z and Yildiz S. The effect of swaddling on pain, vital signs, and crying duration during heel lance in newborns. *Pain Manag Nurs* 2017; 18(5): 328–336.
  158. Caglar S, Büyükyılmaz F, Coşansu G, et al. Effectiveness of ShotBlocker for immunization pain in full-term neonates: a randomized controlled trial. *J Perinat Neonatal Nurs* 2017; 31(2): 166–171.
  159. Göl İ and Altuğ Özsoy S. Effects of rapid vaccine injection without aspiration and applying manual pressure before vaccination on pain and crying time in infants. *Worldviews Evid Based Nurs* 2017; 14(2): 154–162.
  160. Erkul M and Efe E. Efficacy of breastfeeding on babies' pain during vaccinations. *Breastfeed Med* 2017; 12: 110–115.
  161. Hashemi F, Taheri L, Ghodsbin F, et al. Comparing the effect of swaddling and breastfeeding and their combined effect on the pain induced by BCG vaccination in infants referring to Motahari Hospital, Jahrom, 2010-2011. *Appl Nurs Res* 2016; 29: 217–221.
  162. Liu M, Zhao L and Li XF. Effect of skin contact between mother and child in pain relief of full-term newborns during heel blood collection. *Clin Exp Obstet Gynecol* 2015; 42(3): 304–308.
  163. Wilson S, Bremner AP, Mathews J, et al. The use of oral sucrose for procedural pain relief in infants up to six months of age: a randomized controlled trial. *Pain Manag Nurs* 2013; 14(4): e95–e105.
  164. Desjardins MP, Gaucher N, Curtis S, et al. A randomized controlled trial evaluating the efficacy of oral sucrose in infants 1 to 3 months old needing intravenous cannulation. *Acad Emerg Med* 2016; 23(9): 1048–1053.
  165. Suchitra E and Srinivasan R. Effectiveness of dry heat application on ease of venepuncture in children with difficult intravenous access: a randomized controlled trial. *J Spec Pediatr Nurs* 2020; 25: e12273.
  166. Vu-Ngoc H, Uyen NCM, Thinh OP, et al. Analgesic effect of non-nutritive sucking in term neonates: a randomized controlled trial. *Pediatr Neonatol* 2020; 61(1): 106–113.
  167. Koc Ozkan T and Balci S. The effect of acupressure on acute pain during venipuncture in children: implications for evidence-based practice. *Worldviews Evid-Based Nurs* 2019; 17(3): 221–228.
  168. Razaghi N, Aemmi SZ, Sadat Hoseini AS, et al. The effectiveness of familiar olfactory stimulation with lavender scent and glucose on the pain of blood sampling in term neonates: a randomized controlled clinical trial. *Complement Ther Med* 2020; 49: 102289.
  169. KarabykOgurlu O and TuralBuyuk EYO. The effect of warm compression applied before heel lance on pain level, comfort level and procedure time in healthy term newborns: a randomized clinical trial. *J Midwifery Reprod Health* 2020; 8(3): 1.
  170. Beiranvand S, Faraji Goodarzi M and Firouzi M. The effects of caressing and hugging infants to manage the pain during venipuncture. *Compr Child Adolesc Nurs* 2020; 43(2): 142–150.
  171. Koç Özkan T and Polat F. The effect of virtual reality and kaleidoscope on pain and anxiety levels during venipuncture in children. *J Perianesth Nurs* 2020; 35(2): 206–211.
  172. Gerçeker GÖ, Binay Ş, Bilsin E, et al. Effects of virtual reality and external cold and vibration on pain in 7- to 12-year-old children during phlebotomy: a randomized controlled trial. *J Perianesth Nurs* 2018; 33(6): 981–989.
  173. İnangil D, Şendir M and Büyükyılmaz F. Efficacy of cartoon viewing devices during phlebotomy in children: a randomized controlled trial. *J Perianesth Nurs* 2020; 35(4): 407–412.
  174. Semerci R and Akgün Kostak M. The efficacy of distraction cards and kaleidoscope for reducing pain during phlebotomy: a randomized controlled trial. *J Perianesth Nurs* 2020; 35(4): 397–402.
  175. Aydın Aİ and Özyazıcıoğlu N. Using a virtual reality headset to decrease pain felt during a venipuncture procedure in children. *J Perianesth Nurs* 2019; 34(6): 1215–1221.
  176. Duzkaya D, Bozkurt G, Ulupinar S, et al. The effect of a cartoon and an information video about intravenous insertion on pain and fear in children aged 6 to 12 years in the pediatric emergency unit: a randomized controlled trial. *J Emerg Nurs* 2020; 47(1): 76–87.

177. Wong C, Li CK, Chan CWH, et al. Virtual reality intervention targeting pain and anxiety among pediatric cancer patients undergoing peripheral intravenous cannulation: a randomized controlled trial. *Cancer Nurs* 2020; 44(6): 435–442.
178. Inal S and Kelleci M. The effect of external thermomechanical stimulation and distraction on reducing pain experienced by children during blood drawing. *Pediatr Emerg Care* 2020; 36(2): 66–69.
179. Chang J, Filoteo L and Nasr AS. Comparing the analgesic effects of four nonpharmacologic interventions on term newborns undergoing heel lance: a randomized controlled trial. *J Perinat Neonatal Nurs* 2020; 34(4): E22–E45.
180. Yildizeli Topcu S, Akgun Kostak M, Semerci R, et al. Effect of gum chewing on pain and anxiety in Turkish children during intravenous cannulation: a randomized controlled study. *J Pediatr Nurs* 2020; 52: e26–e32.
181. Chen Y, Cheng S, Lee P, et al. Distraction using virtual reality for children during intravenous injections in an emergency department: a randomised trial. *J Clin Nurs* 2020; 29(3–4): 503–510.
182. Aykanat Girgin B and Göl İ. Reducing pain and fear in children during venipuncture: a randomized controlled study. *Pain Manag Nurs* 2020; 21(3): 276–282.
183. Arıkan A and Esenay FI. Active and passive distraction interventions in a pediatric emergency department to reduce the pain and anxiety during venous blood sampling: a randomized clinical trial. *J Emerg Nurs* 2020; 46(6): 779–790.
184. Semerci R, Akgün Kostak M, Eren T, et al. Effects of virtual reality on pain during venous port access in pediatric oncology patients: a randomized controlled study. *J Pediatr Oncol Nurs* 2021; 38: 142–151.
185. Reddy H. V R, Rajan A and Rao Aroor A. Eutectic mixture of prilocaine and lignocaine (2.5%) versus 5% lignocaine versus placebo for pain relief in new-borns undergoing venipuncture: a hospital based, double blind randomised case control study. *Int J Contemp Pediatr* 2019; 6(3): 1014.
186. Orhan E and Yildiz S. The effects of pre-intervention training provided through therapeutic play on the anxiety of pediatric oncology patients during peripheral catheterization. *Int J Caring Sci* 2017; 10(3): 1533–1544.
187. Kuo HC, Pan HH, Creedy DK, et al. Distraction-based interventions for children undergoing venipuncture procedures: a randomized controlled study. *Clin Nurs Res* 2018; 27(4): 467–482.
188. Kassab M, Almomani B, Nuseir K, et al. Efficacy of sucrose in reducing pain during immunization among 10- to 18-month-old infants and young children: a randomized controlled trial. *J Pediatr Nurs* 2020; 50: e55–e61.
189. Canadian Vascular Access Association. Canadian vascular access and infusion therapy guidelines. Pembroke, ON: Pappin Communications; 2019.
190. Gorski LA, Hadaway L, Hagle ME, et al. Infusion therapy standards of practice, 8th edition. *J Infus Nurs* 2021; 44(1S Suppl 1): S1–S224.
191. Carr PJ, Higgins NS, Cooke ML, et al. Vascular access specialist teams for device insertion and prevention of failure. *Cochrane Database Syst Rev* 2018; 3(3): CD011429.
192. Centers for Disease Control and Prevention. Central line-associated bloodstream infections: resources for patients and healthcare providers. <https://www.cdc.gov/hai/bsi/clabsi-resources.html> (2011).
193. Dhingra N, Diepart M, Dziekan G, et al. *WHO guidelines on drawing blood: best practices in phlebotomy*. Geneva: World Health Organization; 2010.
194. Ray-Barruel G, Cooke M, Chopra V, et al. The I-DECIDED clinical decision-making tool for peripheral intravenous catheter assessment and safe removal: a clinimetric evaluation. *BMJ Open* 2020; 10(1): e035239.
195. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *New Engl J Med* 2006; 355(26): 2725–2732.
196. Schuster C, Stahl B, Murray C, et al. Development and testing of an instrument to measure short peripheral catheter insertion confidence. *J Infus Nurs* 2016; 39(3): 159–165.
197. Buljac-Samardzic M, Doekhie KD and van Wijngaarden JDH. Interventions to improve team effectiveness within health care: a systematic review of the past decade. *Hum Resour Health* 2020; 18(1): 2.
198. Bardin-Spencer AJ and Spencer TR. Arterial insertion method: a new method for systematic evaluation of ultrasound-guided radial arterial catheterization. *J Vasc Access* 2021; 22(5): 733–738.
199. Buetti N, Ruckly S, Lucet JC, et al. Ultrasound guidance and risk for intravascular catheter-related infections among peripheral arterial catheters: a post-hoc analysis of two large randomized-controlled trials. *Ann Intensive Care* 2020; 10(1): 89.
200. Shiloh AL, Savel RH, Paulin LM, et al. Ultrasound-guided catheterization of the radial artery: a systematic review and meta-analysis of randomized controlled trials. *Chest* 2011; 139(3): 524–529.
201. Kleidon TM, Schults J, Paterson R, et al. Comparison of ultrasound-guided peripheral intravenous catheter insertion with landmark technique in paediatric patients: a systematic review and meta-analysis. *J Paediatr Child Health* 2022; 58(6): 953–961.
202. Registered Nurses' Association of Ontario. Assessment and management of pain (third edition), <https://rnao.ca/bpg/guidelines/assessment-and-management-pain> (2013, accessed 26 August 2022).
203. Registered Nurses' Association of Ontario. Long-term care best practices toolkit, 2nd edition, <https://ltctoolkit.rnao.ca/resources/pain-assessment-and-management> (2018, accessed 26 August 2022).