Review

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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.[1] Reliable vascular access is fundamental for safe and effective care.[2] Complications associated with

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Table 1. Research questions.

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?

VADs include catheter occlusion, catheter breakage/leakage, bleeding, thrombosis, perforated vessels, phlebitis, infiltration, and extravasation.[3,4] 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.[5] 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[6] and Assessment and Device Selection for Vascular Access.[7] 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.[8] For a more detailed description of the methods, please refer to the full BPG published elsewhere.[5]

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.[5] 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.

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,[9] non-randomized studies using the ROBINS-I tool,[10] and SRs using the ROBIS tool.[11] The certainty of the evidence per outcome was determined by two reviewers using the GRADE approach,[8] which includes 5 components: risk of bias, inconsistency, imprecision, indirectness, and publication bias.[8] GRADE categorizes the overall certainty of evidence as high, moderate, low, or very low (see Table 2).[8] 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.[8] 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.[8] 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.[8] 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.[5]

Recommendation 1.1: Education for persons and their families

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

Evidence suggests that comprehensive health teaching may reduce complications and hospital re-admission rates.[12–22] 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.[23]

Recommendation 2.1: Practical education for health providers

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

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.[24–58] 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.[60–67] Most studies focused on the insertion and management of CVADs, including PICCs,[60–63,67] and three studies focused on PVADs.[64–66] 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.[60–67] 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.[68–71] 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.[68,69,71] However, one study also suggests that venipuncture for blood draws may reduce person satisfaction when compared with drawing blood from a VAD.[69] 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.[65,72–83] Studies examined multi-component care protocols which involved PVAD daily review and documentation.[65,72–83]

At a minimum, daily review involved an assessment of signs and symptoms of PVAD complications.[65,72–83] 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.[65,72–83] 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.[84–89] 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.[84–89] 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.[90–98] 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.[90–92,94–98] 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.[99–124] The majority of pharmacological studies focused on topical anesthetics.[99,100,104–108,111] Non-pharmacological interventions included physical and psychological interventions (e.g. distraction techniques, acupressure, heat, or cold).[100,102,103,109,111–124] Evidence suggests that both pharmacological and non-pharmacological pain management interventions probably decrease pain, fear and anxiety, increase person satisfaction, and may increase comfort.[99–124] 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.[101,103,113,125–185] The majority of studies examined non-pharmacological interventions[101,103,127–135,137,139–183,186–188] which varied with child/infant age and developmental stage. Various pharmacological interventions were used in the studies.[103,125,126,138,185] Evidence suggests that both pharmacological and non-pharmacological pain management interventions may decrease pain[101,103,125–134,178–185] fear and anxiety,[129,131,133,181–183] and increase comfort,[169] and they probably increase person or parent/guardian satisfaction.[101] 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[6,7] 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.[5] Additionally, the full BPG includes a

workflow algorithm for the order of recommendations in practice.[5]

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.[12–15] 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.[5] There are also harms associated with not providing health teaching, including device failure or complications.[5] The Canadian Vascular Access Association (CVAA) infusion therapy guidelines include patient education as a core practice[189] and the Infusion Nurses Society (INS) standards of practice include a standard for patient education that includes topics and teaching strategies.[190]

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.[5] The expert panel felt practical education provided benefits that can improve outcomes. The literature indicated that education is highly valued by health providers,[37,42,47,52,53,55,56] and may improve the confidence and attitude of the provider.[5] Provision of education aligns with the CVAA guidelines,[189] which outline organizational and health provider responsibilities related to education and competency development and maintenance.[189] 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.[190]

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.[5] A Cochrane report investigating VAST published similar findings due to lack of randomized trials.[191] The evidence reviewed for this recommendation was suggestive of reduced complications by using specially trained health providers.[60–63,65,67] This view of greater safety with VAST was also supported by the Centers for Disease Control 2011 guidelines.[192] In the CVAA guidelines, a section is dedicated to outlining clinical responsibilities and practices of a VAS service.[189] 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.[5]

Recommendation 4.1: Blood draws

The evidence suggests that venipuncture may reduce specimen rejection and contamination compared to drawing blood from VADs.[68,69,71] However, venipuncture for drawing blood samples may reduce person satisfaction when compared to drawing blood from VADs.[69] The certainty of the evidence was very low.[5] 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).[5] 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.[5] Practice guidelines from CVAA, INS, and the World Health Organization provide standards and procedures to support practices when drawing blood from VADs.[189,190,193]

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.[194] 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.[194] 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.[190,195–197] 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.[198–200] 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.[98,190,201] 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.[90–92,94–98] 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.[5] The support of these recommendations aligns with the CVAA guideline,[189] INS guideline,[190] RNAO Assessment and Management of Pain BPG,[202] and RNAO's Long-term Care Best Practices Toolkit.[203] Pain management interventions may decrease fear, anxiety, pain and increase comfort and person/family satisfaction during the insertion of VADs throughout the lifespan.[5]

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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N. Moureau reports employee status and ownership of PICC Excellence Inc. Consulting fees are received to PICC Excellence from 3M, Bedal, Chiesi Laboratories, Access Vascular Inc., Accuvein, Linear Health Sciences, Nexus Medical, Parker Laboratories, and Teleflex. None of the other authors declare any potential conflicts of interest.

Declaration of conflicting interests

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Supplemental material

Supplemental material for this article is available online.

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