Review

JVA The Journal of Vascular Access

The pediatric DAV-expert algorithm: A GAVeCeLT/GAVePed consensus for the choice of the most appropriate venous access device in children

The Journal of Vascular Access
1–11

DOI: 10.1177/11297298241256999
journals.sagepub.com/home/jva
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Mauro Pittiruti[1], Alessandro Crocoli[2], Clelia Zanaboni[3], Maria Giuseppina Annetta[4], Michela Bevilacqua[5], Daniele G Biasucci[6], Davide Celentano[7], Simone Cesaro[8], Antonio Chiaretti[9], Nicola Disma[10], Aldo Mancino[11], Cristina Martucci[2], Lidia Muscheri[11], Alessio Pini Prato[12], Alessandro Raffaele[13], Simone Reali[2], Francesca Rossetti[14], Giancarlo Scoppettuolo[15], Luca Sidro[16], Geremia Zito Marinosci[16] and Gilda Pepe[1]

Abstract

In pediatric patients, the choice of the venous access device currently relies upon the operator's experience and preference and on the local availability of specific resources and technologies. Though, considering the limited options for venous access in children if compared to adults, such clinical choice has a great critical relevance and should preferably be based on the best available evidence. Though some algorithms have been published over the last 5 years, none of them seems fully satisfactory and useful in clinical practice. Thus, the GAVePed—which is the pediatric interest group of the most important Italian group on venous access, GAVeCeLT—has developed a national consensus about the choice of the venous access device in children. After a systematic review of the available evidence, the panel of the consensus (which included Italian experts with documented competence in this area) has provided structured recommendations answering 10 key questions regarding the choice of venous access both in emergency and in elective situations, both in the hospitalized and in the non-hospitalized child. Only statements reaching a complete agreement were included in the final recommendations. All recommendations were also structured as a simple visual algorithm, so as to be easily translated into clinical practice.

[1]Department of Surgery, Catholic University Hospital "A.Gemelli," Rome, Italy
[2]Surgical Oncology Unit, Bambino Gesù Children Hospital IRCCS, Rome Italy
[3]Department of Anesthesia and Intensive Care, University Hospital, Parma, Italy
[4]Department of Anesthesia and Intensive Care, Catholic University Hospital "A.Gemelli," Rome, Italy
[5]Vascular Access Team, Gaslini Children Hospital IRCCS, Genova, Italy
[6]Department of Clinical Science and Translational Medicine, "Tor Vergata" University, Rome, Italy
[7]Department of Oncology, Catholic University Hospital "A.Gemelli," Rome, Italy
[8]Department of Pediatric Oncology and Hematology, University Hospital, Verona, Italy
[9]Department of Pediatrics, Catholic University Hospital "A.Gemelli," Rome, Italy
[10]Unit for Research in Anaesthesia, Gaslini Children Hospital IRCCS, Genova, Italy
[11]Pediatric Intensive Care Unit, Catholic University Hospital "A.Gemelli," Rome, Italy
[12]Pediatric Surgery Unit, Umberto Bosio Center for Digestive Diseases, Children Hospital, Alessandria, Italy
[13]Pediatric Surgery Unit, Department of Maternal and Child Health, San Matteo Hospital IRCCS, Pavia, Italy
[14]Department of Anesthesia and Intensive Care, Meyer Children Hospital IRCCS, Firenze, Italy
[15]Infectious Diseases Unit, Catholic University Hospital "A.Gemelli," Rome, Italy
[16]Department of Anesthesia and Intensive Care, Santobono-Pausilipon Children Hospital, Napoli, Italy

Corresponding author:
Mauro Pittiruti, Department of Surgery, Catholic University Hospital "A.Gemelli," Largo F.Vito 1, Roma 00168, Italy.
Email: mauropittiruti@me.com

Keywords
Pediatric, venous access, central venous catheterization, PICC, midline catheters, ultrasound, vascular access, algorithm, decision making

Date received: 11 March 2024; accepted: 7 May 2024

Introduction

The choice of the most appropriate venous access device (VAD) is particularly challenging in children. In fact, in this population, though a reliable venous access is often necessary for blood sampling and/or for the infusion of drugs, fluids, parenteral nutrition, and blood products, the venous patrimony is limited, and VADs are prone to frequent complications.

A paper published in 2019 by the VANGUARD taskforce of the Society of Interventional Radiology[1] has addressed this issue, but its recommendations are today obsolete and antiquate: (a) the authors claim that venography should be used as primary modality to survey the venous system, while all current guidelines recommend ultrasound; (b) venous cannulation by landmark-based "blind" venipuncture or by surgical cutdown is still considered an option; (c) fluoroscopy during insertion—which is currently discouraged by all recent guidelines—is recommended; (d) tunneled non-cuffed central catheters are not considered at all: the only tunneled catheters—in the authors' vision—are tunneled-cuffed; (e) the authors recommend to consider antimicrobial impregnated catheters in high risk patients, while strong evidence of the efficacy of these devices is missing in the pediatric patients; (f) femoral access is not even mentioned.

Another paper published in 2020 (so-called "Mini-MAGIC")—which addresses specifically and systematically the topic of the choice of VAD in the pediatric patient[2]—has also many relevant limitations: (a) the appropriateness of the device is considered almost exclusively on the basis of the duration of treatment; (b) there is confusion in terminology, since there is no clear differentiation between long peripheral catheters (a.k.a. "mini-midlines") and midline catheters (a.k.a. "midclavicular"); also the term "central VADs" is used inappropriately for indicating exclusively centrally inserted central catheters (CICC); (c) many technological novelties (e.g. tunneling), which have recently expanded the indications of peripherally inserted central catheters (PICC) and femorally inserted central catheters (FICC), are not taken into consideration; (d) "tunneled central VADs" are automatically considered as "tunneled-cuffed central VADs" only, while there is a vast recent experience—also in pediatrics—on the use of tunneled, non-cuffed central VADs; (e) issues regarding the material (silicon vs polyurethane, power injectability, etc.) and the design (valved vs non-valved) of the VADs are not considered, though they have a great impact on the performance of the device; (f) last, the recommendations are summarized in a series of algorithms which are complex to read and difficult to apply in clinical practice.

In 2020, AIEOP (The Italian Association of Pediatric Oncology) has published a guideline document[3] about choice, insertion and management of central VADs in the pediatric population: contrary to the aforementioned documents, the AIEOP guidelines are methodologically correct and designed to be useful in clinical practice, since they address all the novelties of the last decade; though, they have the limit of focusing exclusively on central venous access in cancer patients, not addressing venous access in emergency or peripheral venous access devices.

Since 2018, the Italian Group of Venous Access Devices (GAVeCeLT), has issued its recommendations about the choice of venous access in neonates, children, and adults, as an expert system (so-called "DAV-Expert") freely available on internet.[4] In 2023, the Italian Group of Pediatric Venous Access (GAVePed), in collaboration with the interest group of vascular access of the Italian Society of Neonatology has published a consensus which has systematically re-evaluated the recommendations of "DAV-Expert" on neonatal venous access.[5] After the completion of such neonatal project, GAVePed has developed an evidence-based consensus document to re-assess systematically the recommendations of "DAV-Expert" regarding pediatric venous access. The results of this latter project are presented in this paper.

Methods

Considering the impact of this topic on the daily clinical practice and the lack of evidence from high-quality studies, a consensus was thought to be the most appropriate tool for providing robust recommendations. The consensus was promoted and coordinated by three members of GAVePed (MP, AC, and CZ). A panel of experts was identified, choosing the panelists among the Italian vascular access experts who had published papers on peer-reviewed journals about pediatric vascular access in the last few years: 17 experts were identified as potential panelists and all of them accepted the task.

The consensus was structured in different steps, mainly using e-mail, web-based meetings, and live meetings. Initially, a literature search was performed independently by the chairs of the panel (MP, AC, and CZ), with the assistance of a clinician with specific experience in bibliography search (GP). The search was carried out using

PubMed, OVID, Elsevier, and Cochrane Library, evaluating all randomized and observational studies on pediatric venous access published in English language from January 2000 to April 2023. Keywords such as "venous catheter," "peripheral venous catheter," "central venous catheter," "tunneled catheter," "peripherally inserted central venous catheter," "centrally inserted central catheter," "femorally inserted central catheter," "ports," etc., were matched with "children," "pediatric," "pediatric intensive care unit," "pediatric emergency," and others. Papers regarding neonatal patients (age less than 30 days) were excluded. Studies focusing on peripheral arterial catheters, and pulmonary artery catheters were also excluded. References of articles, previous reviews, and meta-analyses were also analyzed, so as not to miss relevant papers.

The consensus process was carried out according to the RAND/University of California at Los Angeles (UCLA) Appropriateness Methodology as a three-step consensus process.[6] The method is a modification of the Delphi method, a structured process for collecting knowledge from groups of experts through a series of questionnaires. First, the coordinators of the panel proposed to develop the document as answers to 10 questions regarding the choice of VADs in children: (1) Which venous access is appropriate in pediatric emergencies? (2) Which is the current indication to peripheral venous access devices in the hospitalized child? (3) Which is the current indication to long peripheral catheters in the hospitalized child? (4) Which are the criteria for choosing the type of central VAD (PICC vs CICC vs FICC)? (5) Which are the appropriate indications to tunneling a central VAD in a hospitalized child? (6) Which type of central VADs is most appropriate in the pediatric patient, in terms of material and technique of insertion? (7) Which is the current role of silicone catheters in the pediatric patient? (8) Which are the proper indications to midline catheters in the pediatric patient who is not hospitalized? (9) Which is the proper indication of tunneled central VADs in the pediatric patient who is not hospitalized? (10) Which are the proper indications of totally implanted central VADs in the pediatric patient who is not hospitalized?

After a preliminary email-based discussion, the whole panel agreed to structure the recommendations as answers to these 10 questions, which were formally approved by every panelist. The panel decided to exclude questions addressing some special central venous access devices used infrequently in children—such as dialysis catheters, ECMO cannulas, and catheters for extracorporeal blood purification—considering that the available literature and the clinical experience are still scarce in regard. Based on the collected literature—which had been previously shared with the whole panel—the three coordinators wrote a preliminary draft of statements, specifically answering the 10 questions. These preliminary statements were e-mailed to the whole panel; each panelist was asked to state her/his level of agreement with each statement (disagree, uncertain, agree) and to provide additional comments, especially in cases of uncertainty or disagreement, and to propose changes of the statement. After collecting the answers of each member of the panel, a first web-based meeting was organized, and all the controversies were discussed collegially. At this point, a second document was arranged, modifying the statements according to the suggestions of the panel, and presented to the panel for approval. After a second live meeting, the final statements were defined and a final survey was sent to each panelist, asking each one to state her/his level of agreement with each new statement (disagree, uncertain, agree). Statements which received 70%–89% of "agree" were considered to be expression of "agreement," statements with 90%–100% of "agree" were considered as "strong agreement." As the voting members of the panel were 20 (17 panelists plus three promoters), "agreement" on a statement corresponded to 14–17 "agree" and "strong agreement" to 18–20 "agree." At the final vote, all statements qualified as "strong agreement," so all of them were included in the recommendations. After the final vote, a preliminary manuscript was sent to the whole panel for review and final approval.

The results of the consensus are presented in the following section, question by question, offering the background knowledge behind each question, the recommendations of the panel, plus some special additional considerations that the panel considered relevant for the proper translation of the recommendations into clinical practice.

Results

Question 1: Which venous access is appropriate in pediatric emergencies?

Background. Both the Mini-MAGIC document[2] and the AIEOP consensus[3] do not address directly this issue. Also, the available literature is scarce and based on questionable or no evidence. The 2021 recommendations of the European Resuscitation Council (ERC)[7,8] and of the Pediatric Advanced Life Support (PALS)[9] suggest that in emergency, after a rapid attempt to achieve a venous access placing a short peripheral cannula (SPC), should this fail, the best strategy is to insert an intraosseous access (IO). Though, this recommendation does not consider the widespread use of ultrasound guidance in the field of pediatrics. No study has compared IO with ultrasound guided peripheral or central venous access in terms of safety, effectiveness, and cost-effectiveness, though indirect data suggest that IO might guarantee a stable (but transitory) access more rapidly. Inevitably, the choice of emergency access cannot ignore the clinical setting, as well as the competences and resources available.[10]

Panel recommendation. In pediatric emergencies, depending on the clinical situation, several types of access may be taken into consideration: (a) intraosseous access, (b) short peripheral cannulas inserted with or without the aid of Near Infra-Red (NIR) technology, (c) long peripheral catheters (a.k.a. "mini-midline") inserted by ultrasound guidance, and

(d) non-tunneled CICCs and FICCs inserted by ultrasound guidance. Central VADs inserted in emergency should be preferably removed within 48 h. *(Strong agreement: 20 agree, 0 uncertain, 0 disagree)*

Special considerations

- The panel considers that in extra-hospital pediatric emergencies and every time the access must be obtained very rapidly, within 1–2 min, IO should be the preferred choice.
- If the superficial veins are not easily cannulated with or without NIR technology,[11] the panel suggest to use ultrasound-guided long peripheral catheters (LPC) rather than ultrasound guided SPCs, since they are associated with less risk of dislodgment.
- IO and SPC are accesses characterized by a very short duration; LPCs and central VADs have longer dwelling time, but they should be preferably removed within 48 h, so to reduce the risk of infection, since appropriate strategies of infection prevention may not be fully adopted during an emergency. Ultrasound-guided LPC may be left in place longer than 48 h, only if the available documentation reports that they have been inserted with the proper strategies of infection prevention (hand hygiene, proper skin antisepsis, maximal barrier precautions).

Question 2: Which is the current indication to peripheral venous access devices in the hospitalized child?

Background. The main indications to central venous access include[12]: (a) infusion of solutions which may be associated with endothelial damage if administered peripherally; an updated and complete list of intravenous drugs (neutral, irritant, or vesicant) is contained in a recent paper by the Spanish Society of Pharmacology[13]; (b) anticipated need for frequent blood sampling (i.e. multiple daily sampling); (c) hemodynamic monitoring (measurement of central venous pressure; estimation of oxygen saturation in mixed venous blood; etc.). All of these three conditions frequently occur in pediatric intensive care; (a) and (b) are often present in cancer.[14] A fourth indication to central VAD is an expected long duration of hospitalization, though this issue should be discussed case by case. In the pediatric population, insertion of central VADs is associated with higher costs, higher invasiveness, and higher risk of complications if compared to peripheral VADs, and this should be taken into consideration.

Panel recommendation. In the hospitalized child, in absence of specific indication to a central venous access (infusion of solution non-compatible with the peripheral veins, need for frequent blood sampling, hemodynamic monitoring), peripheral venous access devices such as short peripheral cannulas or long peripheral catheters are the first option. *(Strong agreement: 20 agree, 0 uncertain, 0 disagree)*

Special considerations

- According to the good practice of "proactive vascular planning," the panel suggests to consider also the expected duration of the venous access. Children with expected long hospitalization might be candidate to a central VAD even in absence of specific contraindication to peripheral access.

Question 3: Which is the current indication of long peripheral catheters in the hospitalized child?

Background. According to a recent consensus developed by the World Conference on Vascular Access (WoCoVA),[12] peripheral VADs should be classified as SPCs (<6 cm long), LPCs (6–15 cm long), and midline catheters (MC) (>15 cm long). MC are consistently inserted using ultrasound guidance; LPC and MC can be insert both with or without ultrasound guidance, though the best clinical results are obtained with ultrasound-guidance. In particular, ultrasound-guided LPCs (typically: 3–4 Fr, 7–8 cm) have an important role in children with Difficult Intra-Venous Access (DIVA), where an access to a deep vein of the arm is necessary, since the superficial veins of the upper limb are not visible/palpable. Also, the expected duration of LPCs is significantly longer than SPCs, as they can stay in place 1 or 2 weeks and sometimes even longer.

Panel recommendation. In the hospitalized child with indication to peripheral venous access, ultrasound-guided long peripheral catheters should be considered (a) in children with Difficult Intra-Venous Access, and (b) when the peripheral venous access is expected to be required for more than 1 week. *(Strong agreement: 19 agree, 1 uncertain, 0 disagree)*

Special considerations

- This recommendation is consistent with the similar recommendation of the WoCoVA consensus[12] about the indication of LPCs in adult patients.
- Alongside this generic recommendation, it is important to mention the contraindications to the placement of an LPC: (a) small children who have no deep veins of proper caliber; (b) children with advanced chronic renal failure and possible future need for an arterial-venous fistula (AVF) for hemodialysis; (c) expected long hospitalization (more than 3–4 weeks), i.e., a situation which requires preferably a central VAD.

Question 4: Which are the criteria for choosing the type of central VAD (PICC vs CICC vs FICC)?

Background. According to the WoCoVA[12] and GAVeCeLT[15] classification, external central VADs can be classified as PICCs (cannulation of deep veins of the arm), CICCs (cannulation of deep veins of the supra/infra-clavicular area), and FICCs (cannulation of deep veins of groin and lower limb). While in neonates there are two types of central VADs which do not benefit of ultrasound-guided venipuncture—epicutaneo-cava catheters (ECC) and umbilical venous catheters (UVC)—in infants and children all central VADs must be inserted by ultrasound guided venipuncture,[16] without any exception. If central VADs are inserted with an appropriate insertion bundle, such as the SIC-Ped developed by GAVeCeLT,[17] there is no evidence of difference between PICC, CICC, and FICC, in terms of risk of infection or risk of thrombosis.[18,19] The SIC-Ped bundle consists in a set of recommendations about insertion of PICC, CICC, or FICC in children, which include: pre-procedural ultrasound evaluation of all deep veins; appropriate septic technique; ultrasound-guided venipuncture; intra-procedural tip location by intracavitary ECG[20] or ultrasound[21]; tunneling, so to avoid inappropriate exit sites (for instance, at the neck or at the groin)[22]; sutureless securement, preferably by subcutaneous anchorage[23]; protection of the exit site with cyanoacrylate glue[24] and semipermeable transparent dressing. Nonetheless, some sites of venipuncture may be associated with increased risk of immediate puncture-related complications (failure of venipuncture, accidental arterial puncture, pleural injury, etc.), while some exit sites may be associated with increased risk of late complications (infection, dislodgment, etc.). Also, the caliber of the veins has an important role not only in the easiness of puncture but also in terms of risk of late complications, since an inappropriate catheter/vein ratio may be associated with venous thrombosis. As in adults, also in children the catheter/vein ratio should be 1:3 or less.[10,15]

Panel recommendation. In children, all central VADs must be inserted by ultrasound guidance; the choice between PICC, CICC, and FICC is based on the available veins—as evaluated by preprocedural ultrasound scan—and on the estimation of the risk of complications related to the venipuncture site and to the exit site. *(Strong agreement: 20 agree, 0 uncertain, 0 disagree)*

Special considerations

- The panel recommends that all central VADs in children should be placed using an appropriate insertion bundle (such as the SIC-Ped protocol)[17] and that the pre-procedural ultrasound evaluation of all venous options should be performed adopting systematic protocols such as RaCeVA (Rapid Central Vein Assessment) for the veins of the supra/infraclavicular area,[25] RaPeVA (Rapid Peripheral Vein Assessment) for the veins of arm,[26] and RaFeVA (Rapid Femoral Vein Assessment) for the veins of the lower limb.[27]
- The panel recommends also an extensive use of tunneling, for the purpose of achieving an ideal exit site regardless of the puncture site, and also for the purpose of reducing the risk of infection, since tunneling significantly decreases bacterial contamination by the extraluminal route.
- The risk of dislodgment, regardless of the exit site, can be minimized by securing the catheter with subcutaneous anchorage.[23,28]

Question 5: Which are the appropriate indications to tunneling a central VAD in a hospitalized child?

Background. Traditionally, tunneling had been regarded as a technique reserved to long term venous access devices, and in most centers tunneling was limited to cuffed catheters. We now appreciate that tunneling is useful also in short term central VADs,[10] since it can move the exit site to more favorable location; such strategy may reduce the risk of infection, dislodgment, and even thrombosis (since catheter-related thrombosis may be caused by excessive instability of the catheter at the exit site). Tunneling is a fast, easy, and safe maneuver which prolongs the duration of the central catheter.[22]

Panel recommendation. In hospitalized children requiring a central VAD (PICC, CICC o FICC), we recommend to tunnel the catheter any time the exit site is not appropriate in terms of stability, easiness of dressing change, and risk of extraluminal contamination. *(Strong agreement: 20 agree, 0 uncertain, 0 disagree)*

Special considerations

- The panel recommends to consider the different tunneling options for PICCs, CICCs, and FICCs as discussed in the RAVESTO protocol.[22]
- The only contraindications to tunneling are: (a) central VADs inserted in emergency without adopting the appropriate strategies of infection prevention (and thus to be removed within 48 h); (b) central VADs inserted in children with abnormal coagulation state (see the GAVeCeLT consensus on the management of the patient with coagulation disorders candidate to venous access).[29]

Question 6: Which type of central VADs is most appropriate in the pediatric patient, in terms of material and technique of insertion?

Background. The main concerns of central VADs in children are: (a) they are often inserted in veins of small caliber, so that the catheter itself must be of relatively

small diameter but yet it must ensure an adequate flow; (b) they are inserted in small, delicate veins, so that small-bore venipuncture needles (21G), of appropriate length, should be preferred; (c) the options for venipuncture are often limited, so that—as already mentioned above—tunneling is frequently indicated to obtain an appropriate exit site. Since the optimal function of the catheter—both in infusion and in aspiration—is of great importance, it also necessary to avoid valved catheters. In fact, while there is no evidence that any valved catheter may reduce the risk of lumen occlusion, there is strong evidence that distal valved "close-ended" catheters are associated with catheter malfunction.[10,15] Last, micro-introducer kits with small-bore needles and non-J guidewires have been advocated, so to reduce the trauma to the vein wall and facilitate the progression of the guidewire.

Panel recommendation. All central VADs in infants and children—PICC o CICC or FICC—should be preferably (a) *power injectable*, (b) in polyurethane, (c) non-valved, (d) inserted using a micro-introducer kit (21G needle, 0.018″ soft straight tip nitinol guidewire), (e) inserted using a modified Seldinger technique (and therefore easy to tunnel). *(Strong agreement: 20 agree, 0 uncertain, 0 disagree)*

Special considerations

- This recommendation is consistent with the AIEOP recommendations in this regard.[3]
- The "off label" use of 3-4-5 Fr power injectable catheters marketed as PICCs for any type of pediatric central VAD insertion (including CICC and FICC) is strongly recommended, since such catheters are invariably equipped with a micro-introducer kit and they are inserted by modified Seldinger technique.

Question 7: Which is the current role of silicone catheters in the pediatric patient?

Background. Several silicone catheters are still available for use in pediatric patients, but the preference of silicone over polyurethane is not supported by any evidence, since no advantage in terms of risk of infection or thrombosis has never been proven.[3,30] On the contrary, silicone catheters have many disadvantages[10]: (a) they have lower flow rates if compared to polyurethane, (b) they are not power injectable, so that they cannot be used for contrast medium infusion during CT scan or MR, (c) they are more prone to secondary malposition (tip migration) because less rigid than polyurethane, (d) they are more prone to rupture and/or mechanical damage of the catheter wall, since they are more fragile than polyurethane, (e) they are more prone to lumen occlusion (since their wall is thicker), (f) they are more difficult to unblock by hydraulic methods, should lumen occlusion occur, (g) they can be damaged by cyanoacrylate, and (h) they are more expensive.

Panel recommendation. In pediatric patients, silicone catheters should always be avoided, since they have no advantage over polyurethane, but they have many disadvantages. *(Strong agreement: 18 agree, 2 uncertain, 0 disagree)*

Special considerations

- This recommendation is consistent with the AIEOP recommendations in pediatric cancer patients, and with the GAVeCeLT recommendations in all patients (neonates, children, and adults).[3,15,31]

Question 8: Which are the proper indications to midline catheters in the pediatric patient who is not hospitalized?

Background. Midline catheters (MC) (a.k.a. midclavicular) are seldom used in pediatric patients, for several reasons: (a) in hospitalized children, for limited periods of time, long peripheral catheters are easier to insert and more cost-effective than MC; (b) in non-hospitalized children who require a peripheral venous access for weeks or months, usually a PICC is preferred, since it is more reliable for blood sampling and more flexible in terms of the type of solutions to administer; (c) MC are quite long (16–25 cm) and can be taken into consideration only in adolescents: since they are inserted by ultrasound guidance in deep veins at midarm, in small children the catheter is so long that it would reach a central or almost-central position of the tip.

Panel recommendation. Midline catheters ("midclavicular") may be taken into considerations in some selected cases of non-hospitalized children who need a peripheral venous access for a limit period of time (<4 weeks). *(Strong agreement: 19 agree, 1 uncertain, 0 disagree)*

Special considerations

- Conditions for MC use include (a) administration only of infusions compatible with the peripheral route, (b) teenage children with good compliance and collaborative.
- A typical indication of MC are cycles of antibiotic therapy in patients with cystic fibrosis, in the extra-hospital setting, if the antibiotic drug is compatible with the peripheral route. Though, MC may sometimes be indicated also in hospitalized children.
- If MC are used, they must be power injectable, non-valved, and in polyurethane; the location of the tip should be preferably verified by ultrasound[32] and the catheter secured by subcutaneous anchorage.[23,28]

Question 9: Which are the proper indications of tunneled central VADs in the pediatric patient who is not hospitalized?

Background. Tunneling is often preferable in short term central VADs in children, typically when the venipuncture site is not appropriate as exit site, but it is also highly recommended for all medium-long term central VADs to be used in an extra-hospital setting, because of the protective effect of tunneling against extraluminal bacterial contamination.[3]

Panel recommendation. In the non-hospitalized child, external tunneled central VADs are indicated (a) if the patient requires a central venous access for less than 3 months and regardless of how frequently the access is used, or (b) if the patient needs a central venous access for more than 3 months, but to be used frequently (once a week, or more frequently). Tunneled catheters may be PICCs, CICCs, or FICCs, depending on the clinical situation, and they can be either non-cuffed (but secured with subcutaneous anchorage), or cuffed. *(Strong agreement: 19 agree, 1 uncertain, 0 disagree)*

Special considerations

- The panel recommends that all tunneled catheters, either cuffed or non-cuffed, should be inserted using a proper insertion bundle (such as the SIC-Ped protocol),[17] which must necessarily include pre-procedural ultrasound evaluation of the deep veins, ultrasound guided venipuncture, and intra-procedural verification of the position of the tip by intracavitary ECG and/or ultrasound-based tip location.
- There is no strong evidence that may assist in the choice between tunneled-cuffed catheters versus tunneled, non-cuffed catheters secured with subcutaneous anchorage. Still, there are some considerations that suggest that subcutaneous anchorage may be preferable to the cuff as stabilization strategy[10]: (a) placement of a tunneled-cuffed catheter is less easy than placement of a tunneled non-cuffed catheter, since the operator must simultaneously place the tip in the proper location and place the cuff at no less than 1″ from the exit site; (b) securement by subcutaneous anchorage is effective immediately, while securement by cuff requires a few weeks before being effective; (c) any cuff-related complication implies catheter removal, while any complication due to the subcutaneous anchorage can be treated by removing the anchoring system, leaving the catheter in place; (d) removal of tunneled-cuffed catheters requires local anesthesia or sedation, while non-cuffed catheters secured by subcutaneous anchorage can be removed while the child is fully awake, since no traumatic intervention is needed; (e) a tunneled-cuffed catheter costs more than the combined cost of a non-cuffed catheter + a subcutaneous anchoring device.

Question 10: Which are the proper indications of totally implanted central VADs in the pediatric patient who is not hospitalized?

Background. In neonates, totally implanted central VADs (ports) have no indication. In adult patients, they are indicated if venous access is scheduled for prolonged time (>3 months), with infrequent use of the device (typically, less frequently than once a week). In infants and children, indication of ports is theoretically similar to indication in adult patients, though their use is often limited by several considerations[10]: (a) the inevitable "needle-phobia" of the pediatric patient, since the access to a port always implies a percutaneous puncture with the Huber needle; (b) the limited availability of veins of appropriate caliber, especially in infants and small children, (c) the technical challenge of the subcutaneous insertion of the reservoir in small children, (d) the limited duration of the device, since as the child grows the tip of the catheter will invariably migrate to a less deep position, at the point of being not "central" anymore.

Panel recommendation. In the non-hospitalized child, totally implanted central VADs are indicated if the patient requires a central venous access for more than 3 months and if the access is scheduled to be used infrequently (less frequently than once a week). Totally implanted central VADs may be PICC-ports, chest-ports, or femoral ports, depending on the clinical situation, and the availability of veins of appropriate caliber. *(Strong agreement: 20 agree, 0 uncertain, 0 disagree)*

Special considerations

- Though this is a general indication consistent with most international guidelines, the choice of a port versus a tunneled catheter must obviously take into consideration also the preference of the patient and of the family.
- The panel recommends that all ports should be inserted using a proper insertion bundle, which must necessarily include pre-procedural ultrasound evaluation of the deep veins, ultrasound guided venipuncture, and intra-procedural verification of the position of the tip by intracavitary ECG and/or ultrasound-based tip location.
- Considering the physical constitution of children, ports will be rarely indicated in small infants. In older children and teenagers, very low-profile reservoirs (approximately 8 mm high) and 5 Fr polyurethane catheters are usually indicated.
- The correct tip position of the port should be reassessed at least once per year, especially in the fast-growing child.

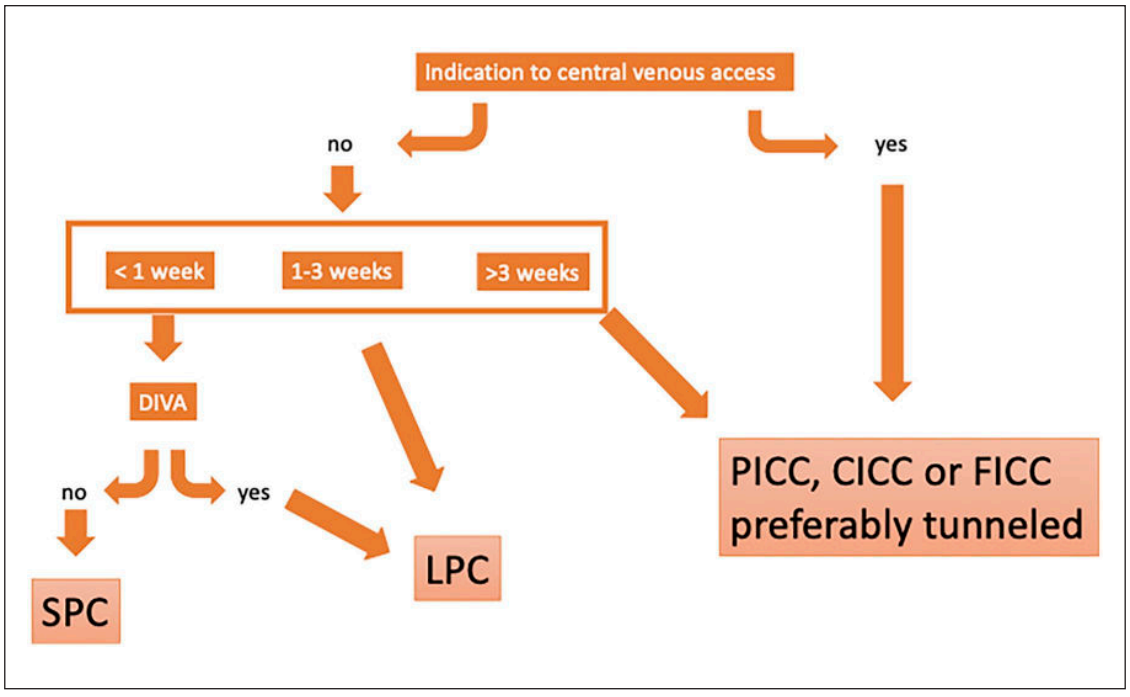

Figure 1. Choice of venous access device in hospitalized pediatric patients.

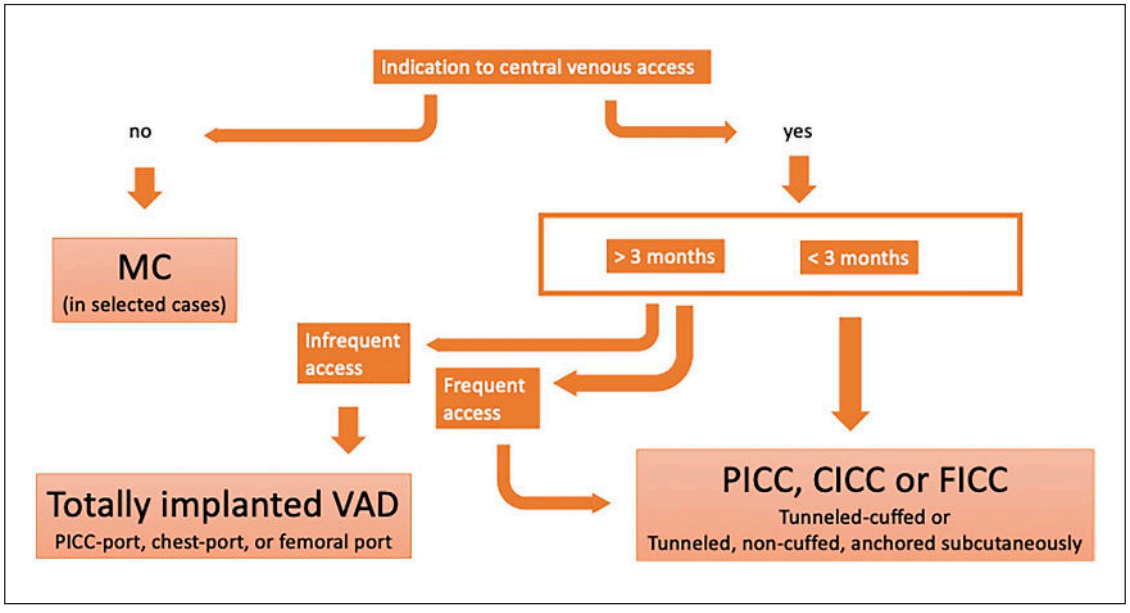

Figure 2. Choice of venous access device in non-hospitalized pediatric patients.

Summary of the panel recommendations

All the recommendations made by the panel have been summarized in the form of an algorithm, addressing separately the intrahospital (Figure 1) and the extra-hospital setting (Figure 2). The panel recommendations are reported in Table 1. The pediatric DAV-expert algorithm, as developed by this GAVeCeLT/GAVePed consensus, is currently part of the DAV-Expert algorithm (available in five languages at the permanent link http://davexpert.gavecelt.it/).

Table 1. Panel recommendations.

1: Which venous access is appropriate in pediatric emergencies?
In pediatric emergencies, depending on the clinical situation, several types of access may be taken into consideration: (a) intraosseous access, (b) short peripheral cannulas inserted with or without the aid of Near Infra-Red (NIR) technology, (c) long peripheral catheters (a.k.a. "mini-midline") inserted by ultrasound guidance, and (d) non-tunneled CICCs and FICCs inserted by ultrasound guidance. Central VADs inserted in emergency should be preferably removed within 48 h.
2: Which is the current indication to peripheral venous access devices in the hospitalized child?
In the hospitalized child, in absence of specific indication to a central venous access (infusion of solution non-compatible with the peripheral veins, need for frequent blood sampling, hemodynamic monitoring), peripheral venous access devices such as short peripheral cannulas or long peripheral catheters are the first option.
3: Which is the current indication of long peripheral catheters in the hospitalized child?
In the hospitalized child with indication to peripheral venous access, ultrasound-guided long peripheral catheters should be considered (a) in children with Difficult Intra-Venous Access, and (b) when the peripheral venous access is expected to be required for more than 1 week.
4: Which are the criteria for choosing the type of central VAD (PICC vs CICC vs FICC)?
In children, all central VADs must be inserted by ultrasound guidance; the choice between PICC, CICC, and FICC is based on the available veins—as evaluated by preprocedural ultrasound scan—and on the estimation of the risk of complications related to the venipuncture site and to the exit site.
5: Which are the appropriate indications to tunneling a central VAD in a hospitalized child?
In hospitalized children requiring a central VAD (PICC, CICC o FICC), we recommend to tunnel the catheter any time that the most appropriate venipuncture site is not an appropriate exit site in terms of stability, easiness of dressing change, and risk of extraluminal contamination.
6: Which type of central VADs is most appropriate in the pediatric patient, in terms of material and technique of insertion?
All central VADs in infants and children—PICC o CICC or FICC—should be preferably (a) *power injectable*, (b) in polyurethane, (c) non-valved, (d) inserted using a micro-introducer kit (21G needle, 0.018″ soft straight tip nitinol guidewire), (e) inserted using a modified Seldinger technique (and therefore easy to tunnel).
7: Which is the current role of silicone catheters in the pediatric patient?
In pediatric patients, silicone catheters should always be avoided, since they have no advantage over polyurethane, but they have many disadvantages. *(Strong agreement)*
8: Which are the proper indications to midline catheters in the pediatric patient who is not hospitalized?
Midline catheters ("midclavicular") may be taken into considerations in some selected cases of non-hospitalized children who need a peripheral venous access for a limit period of time (<4 weeks).
9: Which are the proper indications of tunneled central VADs in the pediatric patient who is not hospitalized?
In the non-hospitalized child, external tunneled central VADs are indicated if the patient requiring a central venous access for less than 3 months, regardless of how frequently the access is used, or if the patient needs a central venous access for more than 3 months, frequently used (once a week or more frequently). Tunneled catheters may be PICCs, CICCs, or FICCs, depending on the clinical situation, and they can be either non-cuffed (but secured with subcutaneous anchorage), or cuffed.
10: Which are the proper indications of totally implanted central VADs in the pediatric patient who is not hospitalized?
In the non-hospitalized child, totally implanted central VADs are indicated if the patient requires a central venous access for more than 3 months and if the access is scheduled to be used infrequently (less frequently than once a week). Totally implanted central VADs may be PICC-ports, chest-ports, or femoral ports, depending on the clinical situation, and the availability of veins of appropriate caliber. *(Strong agreement)*

Conclusions

The goal of the present consensus is to offer a systematic set of recommendations on the choice of the most appropriate VAD in the pediatric patient. The DAV-expert algorithm, however, should not be considered as a reference guideline, nor as a shortcut for an automatic clinical choice; instead, it should be regarded as a tool to facilitate clinical reasoning in potentially complex situations, in which the clinician must consider all the possible solutions and the pros and cons of each choice. In fact, the selection of the most appropriate VAD will always be a clinical decision that the healthcare professional (physician or nurse) must take on a case-by-case basis, after assessing the needs of the individual patient and the local resources.

Last, the pediatric DAV-expert algorithm is conceived as an open system. Since the field of venous accesses is constantly evolving, the algorithm should not be interpreted as a static dogma but rather as a dynamic and evolving instrument, up to date with the international literature that continually proposes new solutions, new devices, and new evidence.

Author contributions

MP, AC, and CZ contributed to the study's conception and design. MP and GP performed the literature research. All the other authors had an active part in the construction of the recommendations of the present paper, as explained in the methods section. The first draft of the manuscript was written by MP, AC, and CZ. All authors read and approved the final manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethical approval

Not applicable.

ORCID iDs

Mauro Pittiruti https://orcid.org/0000-0002-2225-7654
Alessandro Crocoli https://orcid.org/0000-0003-2157-4233
Maria Giuseppina Annetta https://orcid.org/0000-0001-7574-1311
Daniele G Biasucci https://orcid.org/0000-0001-6839-2416
Simone Cesaro https://orcid.org/0000-0002-8698-9547
Cristina Martucci https://orcid.org/0000-0002-0037-4534

References

1. Baskin KM, Mermel LA, Saad TF, et al. Evidence-based strategies and recommendations for preservation of central venous access in children. *JPEN J Parenter Enteral Nutr* 2019; 43(5): 591–614.
2. Ullman AJ, Bernstein SJ, Brown E, et al. The Michigan appropriateness guide for intravenous catheters in pediatrics: miniMAGIC. *Pediatrics* 2020; 145(Suppl 3): S269–S284.
3. Cellini M, Bergadano A, Crocoli A, et al. Guidelines of the Italian Association of Pediatric Hematology and Oncology for the management of the central venous access devices in pediatric patients with onco-hematological disease. *J Vasc Access* 2022; 23(1): 3–17.
4. Pittiruti M, Potere A and Straccini P. DAV-Expert, http://davexpert.gavecelt.it/ (2021); accessed on January 2024.
5. Barone G, D'Andrea V, Ancora G, et al. The neonatal DAV-expert algorithm: a GAVeCeLT/GAVePed consensus for the choice of the most appropriate venous access in newborns. *Eur J Pediatr* 2023; 182(8): 3385–3395.
6. Brook RH. The RAND/UCLA appropriateness method. In: AHCPR (ed.) *Methodology perspectives*. Rockville, MD: Public Health Service, U.S. Department of Health and Human Services, 1994, pp.59–70.
7. Wyckoff MH, Singletary EM, Soar J, et al. 2021 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations: summary from the Basic Life Support; Advanced Life Support; Neonatal Life Support; Education, Implementation, and Teams; First Aid Task Forces; and the COVID-19 Working Group. *Resuscitation* 2021; 169: 229–311.
8. Van de Voorde P, Turner NM, Djakow J, et al. European resuscitation council guidelines 2021: paediatric life support. *Resuscitation* 2021; 161: 327–387.
9. Merchant RM, Topjian AA, Panchal AR, et al. Part 1: executive summary: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2020; 142: S337–S357.
10. Biasucci DG, Disma NM and Pittiruti M, eds. *Vascular access in neonates and children*. Cham: Springer, 2022.
11. Bailey SM, Prakash SS, Verma S, et al. Near-infrared spectroscopy in the medical management of infants. *Curr Probl Pediatr Adolesc Health Care* 2022; 52(11): 101291.
12. Pittiruti M, Van Boxtel T, Scoppettuolo G, et al. European recommendations on the proper indication and use of peripheral venous access devices (the ERPIUP consensus): a WoCoVA project. *J Vasc Access* 2023; 24(1): 165–182.
13. Manrique-Rodríguez S, Heras-Hidalgo I, Pernia-López MS, et al. Standardization and chemical characterization of intravenous therapy in adult patients: a step further in medication safety. *Drugs R D* 2020; 21: 39–64.
14. Crocoli A, Tornesello A, Pittiruti M, et al. Central venous access devices in pediatric malignancies: a position paper of Italian Association of Pediatric Hematology and Oncology. *J Vasc Access* 2015; 16: 130–136.
15. Pittiruti M and Scoppettuolo G. *The GAVeCeLT manual of PICC and midline: indications, insertion, management*. Milano: Edra, 2017.
16. Lamperti M, Biasucci DG, Disma N, et al. European Society of Anaesthesiology guidelines on peri-operative use of ultrasound-guided for vascular access (PERSEUS vascular access). *Eur J Anaesthesiol* 2020; 37: 344–376.
17. Pittiruti M, Celentano D, Barone G, et al. A GAVeCeLT bundle for central venous catheterization in neonates and children: a prospective clinical study on 729 cases. *J Vasc Access* 2023; 24(6): 1477–1488.
18. Crocoli A, Cesaro S, Cellini M, et al. In defense of the use of peripherally inserted central catheters in pediatric patients. *J Vasc Access* 2021; 22: 333–336.
19. Giordano P, Saracco P, Grassi M, et al. Recommendations for the use of long-term central venous catheter (CVC) in children with hemato-oncological disorders: management of CVC-related occlusion and CVC-related thrombosis. On behalf of the coagulation defects working group and the supportive therapy working group of the Italian Association of Pediatric Hematology and Oncology (AIEOP). *Ann Hematol* 2015; 94: 1765–1776.
20. Rossetti F, Pittiruti M, Lamperti M, et al. The intracavitary ECG method for positioning the tip of central venous access devices in pediatric patients: results of an Italian multicenter study. *J Vasc Access* 2015; 16: 137–143.
21. Zito Marinosci G, Biasucci DG, Barone G, et al. ECHOTIP-Ped: a structured protocol for ultrasound-based tip navigation and tip location during placement of central venous access devices in pediatric patients. *J Vasc Access* 2023; 24(1): 5–13.
22. Ostroff MD, Moureau N and Pittiruti M. Rapid Assessment of Vascular Exit Site and Tunneling Options (RAVESTO): a new decision tool in the management of the complex vascular access patients. *J Vasc Access* 2023; 24(2): 311–317.
23. Crocoli A, Martucci C, Sidro L, et al. Safety and effectiveness of subcutaneously anchored securement for tunneled

central catheters in oncological pediatric patients: a retrospective study. *J Vasc Access* 2023; 24(1): 35–40.
24. Pittiruti M, Annetta MG, Marche B, et al. Ten years of clinical experience with cyanoacrylate glue for venous access in a 1300-bed university hospital. *Br J Nurs* 2022; 31(8): S4–S13.
25. Spencer TR and Pittiruti M. Rapid Central Vein Assessment (RaCeVA): a systematic, standardized approach for ultrasound assessment before central venous catheterization. *J Vasc Access* 2019; 20(3): 239–249.
26. Brescia F, Pittiruti M, Spencer TR, et al. The SIP protocol update: eight strategies, incorporating Rapid Peripheral Vein Assessment (RaPeVA), to minimize complications associated with peripherally inserted central catheter insertion. *J Vasc Access* 2024; 25(1): 5–13.
27. Brescia F, Pittiruti M, Ostroff M, et al. The SIF protocol: a seven-step strategy to minimize complications potentially related to the insertion of femorally inserted central catheters. *J Vasc Access* 2023; 24(4): 527–534.
28. Pinelli F, Pittiruti M, Van Boxtel T, et al. GAVeCeLT-WoCoVA Consensus on subcutaneously anchored securement devices for the securement of venous catheters: current evidence and recommendations for future research. *J Vasc Access* 2021; 22: 716–725.
29. Annetta MG, Bertoglio S, Biffi R, et al. Management of antithrombotic treatment and bleeding disorders in patients requiring venous access devices: a systematic review and a GAVeCeLT consensus statement. *J Vasc Access* 2022; 23(4): 660–671.
30. Ares G and Hunter CJ. Central venous access in children: indications, devices, and risks. *Curr Opin Pediatr* 2017; 29(3): 340–346.
31. Gallieni M, Pittiruti M and Biffi R. Vascular access in oncology patients. *CA Cancer J Clin* 2008; 58(6): 323–346.
32. Elli S, Pittiruti M, Pigozzo V, et al. Ultrasound-guided tip location of midline catheters. *J Vasc Access* 2020; 21(5): 764–768.