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The SaRePo protocol: A seven-step strategy to minimize complications potentially related to the removal of totally implanted central venous access devices

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Abstract

Removal of totally implanted central venous access devices (brachial ports, chest-ports, femoral ports) is potentially associated with the risk of untoward events, some of them negligible (prolonged maneuver time due to technical difficulties), some relevant (hematoma), and some severe (embolization of catheter fragments into the circulation). The removal technique suitable for minimizing such complications has been described only in few manuals, but it has never been standardized. This paper describes a standardized protocol (SaRePo: Safe Removal of Ports) which consists of seven basic strategies to be adopted systematically during removal of totally implanted venous access devices, so to minimize the risk of adverse events. These strategies include: evaluation of the patient's history, preprocedural ultrasound scan of the veins, appropriate aseptic technique, proper local anesthesia, catheter extraction, removal of the reservoir from the pocket, closure of the surgical incision.

Keywords

Totally implanted venous access devices, PICC-port, chest-port, femoral port, port removal

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Introduction

Totally implanted vascular access devices (TIVADs or ports) are commonly used for long term intravenous treatments in non-hospitalized patients (chemotherapy, home parenteral nutrition, prolonged antimicrobial treatments, etc.).[1–3] They consist of a central venous catheter connected to a reservoir, which is placed in a subcutaneous pocket.[4] The reservoir can be placed in different locations: (a) in the infraclavicular area, usually above the great pectoral muscle, after cannulation of an infra/supra-clavicular vein (chest port)[1]; (b) at mid-arm, above the biceps muscle, after cannulation of a deep vein of the arm (PICC port)[5]; (c) at mid arm, above the biceps muscle, after cannulation of an infra/supra-clavicular vein with long tunneling toward the arm (chest-to-arm port)[6]; (d) on the thigh above the quadriceps muscle or on the abdomen, after cannulation of the common or superficial femoral vein (femoral port).[7] Other locations of the reservoir have been described in the past (such as above the trapezius muscle, or in the lateral thoracic area, or above the sternum, etc.), but are rarely adopted in the current clinical practice.

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The indications to port insertion have been discussed in several documents,[3,8] and the technique of implantation has also been standardized in dedicated protocols.[2,5,7,8]

The removal of ports, on the contrary, is not frequently addressed in the literature. Existing recommendations[3,8,9] are mainly focused on the indications for port removal, which include the following conditions:

- When the treatment has been completed. In oncologic patients with ports used for chemotherapy, the current strategy is to remove the device at the end of the treatment, when no further utilization is expected for the next 6–9 months.
- When the device is no longer appropriate. This may happen in a patient who, after using the port for several cycles of chemotherapy, is directed to palliative care; supportive treatments usually require frequent venous access, and port may not be the most appropriate device.
- When there are complications requiring the removal of the device. These include infections, mechanical complications (irreversible occlusion of the lumen, secondary malposition, catheter rupture), exposure of the reservoir (typically, because of relevant weight loss or because of skin erosion due to drug extravasation) and some cases of venous thrombosis (when the thrombus is located at the tip of the catheter and causes malfunction). In case of infectious complications, a multidisciplinary consult with a specialist in infectious disease is mandatory. Salvage of the device with lock therapy is sometimes possible in some situations, and it should be considered if the port is still needed.[10,11]
- When the patient refuses the device. Patients with psychological difficulties in accepting the disease, at some point of the treatment, might ask for the port to be removed even against the advice of the health professionals (who must inform the patient about the negative consequences of such decision).

Many scientific studies have also investigated the prevalence of the different causes for port removal. In a retrospective study published a decade ago,[12] the main causes for port removal were end of treatment (50%), catheter occlusion (25%), extravasation (16%), infection (8%). In a retrospective study on 242 pediatric patients, the reason for removal was a device-related complication in 29% of cases.[13] In a more recent study on 1005 port removals,[14] about 60% of the ports were removed because of completion of therapy while 40% because of complications such as infection (4.7%) or thrombosis (3.6%). In a retrospective study on 2583 patients,[15] the main reasons for removal were end of treatment (88.3%), infection (5.7%), mechanical complications (3.1%), or thrombosis (1.1%). In another recent study on 208 oncologic children,[16] the most frequent cause for removal of long term central venous access devices (including TIVADs but also tunneled CVADs) were end of treatment (69.2%), infection (10.6%), and malfunction (3.4%). Some case reports have discussed other less frequent indications to port removal and/or replacement, such as secondary malposition[17,18] or catheter rupture and embolization.[19]

Few publications discuss the incidence of complications during port removal. In one of these studies,[15] 38 complications were reported during 2583 port removals, with an incidence of 1.47%. The most frequent complication was bleeding (17 patients, 0.66%), which required surgical control of hemostasis in 8 patients; 3 of these patients were on anticoagulation therapy and 3 on antiaggregating drugs. Pocket infection occurred in 8 patients (0.31%), wound dehiscence in 3 patients (0.12%), mechanical complications in 10 patients (0.39%: 9 cases of embolization of catheter fragments and 1 case of failed removal).[15] In a retrospective review of 208 CVAD removals in children (including not only TIVADs but also tunneled CVADs), 20 complications (9.6%) were reported; indwelling time >2 years was associated with a 2.87 increased risk of difficult removal of the CVAD.[16] In a recent retrospective study on the removal of 514 ports, the incidence of difficult removal was 7.4%; indwelling duration, silicone catheter, and local chronic inflammation due to subcutaneous leakage of fluid were identified as significant risk factors for difficult removal.[20] A similar finding had been reported by other authors,[12] which detected a high rate of catheter damage with local granuloma at the entrance of the vein when the catheter attached to the reservoir was a silicone Groshong® catheter. In a review of 98 port removals in pediatric patients, the removal was unsuccessful in eight cases, as the catheter was "stuck" inside the tissues and/or in the vessels.[21] Catheter embolization during the removal has also been reported, with an incidence of 1.8%[22] and 2.2%.[23] In a vast retrospective study on 4954 cases of port removal in breast cancer patients, the incidence of complications was 0.3% (13 cases) including 2 cases of bleeding, 5 cases of difficult removal, and 6 cases of delayed wound healing; the authors reported also 35 cases of catheter fracture/rupture detected at post-removal examination, all of them regarding silicone catheters and associated with longer indwelling time of the device.[24]

Some of these complications may be prevented or anticipated by the proper assessment of the patient's history before removal: a long indwelling time of the device or inappropriate techniques of venipuncture or placement of the reservoir during port implantation may be associated with an increased risk of complications at removal. A recent evidence-based document[25] has provided recommendations regarding the assessment of the coagulation status of the patient, to reduce the risk of bleeding during

removal. It seems logic that removal-related complications may be minimized—or at least predicted—by an appropriate protocol of TIVAD removal, but recommendations are scarce in this regard.

The detailed surgical technique of the removal procedure is rarely addressed in the literature, and almost exclusively in manuals about TIVADs, such as the one published by the Interdisciplinary French Group of Venous Access (GIFAV) in 2019,[1] or the recent one published by the Italian Group of Long-Term Venous Access (GAVeCeLT) in 2024.[2]

In the last few years, GAVeCeLT has developed insertion protocols for different vascular access devices,[26–29] with the purpose of standardizing each vascular procedure and make it safer, by including all the current strategies of complication prevention in operative bundles synthetized in few steps.

In response to the published safe insertion maneuvers, a group of GAVeCeLT experts has developed a novel bundle focused on the procedure of port removal, nicknamed "the SaRePo protocol" (Safe Removal of Port). It consists in seven key recommendations—based on the best available evidence—which aim to minimize the complications (infection, bleeding, catheter embolization, etc.) that may occur during port removal, in all patient populations (both in children and in adults).

The SaRePo protocol

(1) Patient's clinical history. The first step is to verify the proper indication to port removal (end of treatment, or complications requiring removal, or need for a more appropriate device, or patient's decision). Similarly to what recommended for port insertion, the patient's coagulation status should be evaluated. A platelet count below 50×10^9/L or a PT/INR above 1.5 may be considered a contraindication to port removal. In case of low platelet count and strong indication to immediate port removal (e.g. because of infection), platelet transfusion should be considered soon before the maneuver. The antithrombotic treatment or the double antiaggregant therapy—if present—should be withheld according to the recommendations of the above mentioned GAVeCeLT consensus.[25] The clinical history should be investigated also for the purpose or identifying conditions which may be associated with difficult removal: long stay of the device, possible pinch-off due to blind infra-clavicular approach to the subclavian vein, high puncture of the internal jugular vein, catheter made of silicone, reservoir in abnormal location. Preoperative assessment should also include an evaluation of the skin above the reservoir to rule out local inflammation, suppuration, or skin erosion. Preoperative antibiotic is warranted only if the port is removed because of infection. The patient should be fully informed about the technical aspects of the maneuver and should sign a consent form. Removal should be preferably performed in a dedicated procedure room: it is not recommended to perform removal in a surgical theater or in a radiological suite, as the use of these facilities would not increase the safety of the procedure but it would reduce its cost-effectiveness.

(2) Pre-procedural ultrasound scan. Ultrasound scan is useful to rule out unrecognized complications such as secondary malposition of the tip and/or asymptomatic venous thrombosis. Current guidelines do not recommend pre-procedural ultrasound evaluation before removal,[9] but since the maneuver is likely to be performed in a dedicated procedure room equipped with ultrasound devices, a preprocedural scan is logistically sustainable and presumably cost-effective. If a venous thrombosis is identified, a proper anti-thrombotic treatment with low molecular weight heparin or with fondaparinux should be started and port removal should be delayed at least for 72 h. The ultrasound evidence of a particularly florid fibroblastic sleeve along the catheter or of a prominent granuloma at the site where the catheter enters the vein may anticipate difficulty in the extraction of the catheter. A granuloma at the site of venipuncture is often present when the catheter has been inserted by blind infra-clavicular approach to the subclavian vein; in these cases, it is recommended an ultrasound scan of the supraclavicular area, to verify the presence of the catheter in the subclavian and in the brachio-cephalic veins. Failure to visualize the catheter in these supraclavicular veins must prompt a chest radiograph before removal, to rule out catheter fracture secondary to the pinch-off syndrome, with embolization of the distal fragment of the catheter into the heart or into the lungs. If the catheter is visualized in the supraclavicular veins, a bubble test (i.e. rapid infusion of saline mixed with air) should be performed, by placing the linear ultrasound probe under the clavicle: the appearance of micro-bubbles in the subcutaneous tissue is strongly suggestive of a structural damage of the catheter wall, secondary to pinch-off, without embolization.[2] In selected cased, trans-thoracic echocardiography with bubble test may be used to identify the correct catheter tip position before removal.[30]

(3) Proper aseptic technique. "Surgical" hygiene of the hands, skin antisepsis with 2% chlorhexidine in 70% iso-propylic alcohol, and "minimal" barrier precautions are recommended. The operator should

wear a non-sterile cap, non-sterile surgical mask, and sterile gloves. The use of sterile surgical gown is not strictly required. The use of all-inclusive procedural packs simplifies the procedure and reduces the costs: each pack should ideally contain cap, mask, sterile perforated drape, additional sterile drapes, disposable surgical tools (a needle holder, a klemmer, a forceps), a #11 scalpel blade, a 3-0 or 4-0 monofilament adsorbable suture, a 10 mL luer-lock syringe, a 25–27 G needle for local anesthesia, a semi-permeable transparent dressing, some gauzes. Other items may be included or not, depending on local regulatory policies and cost convenience (local anesthetic, chlorhexidine in alcohol, sterile gloves, and cyanoacrylate glue).

(4) Local anesthesia and skin incision. Port removal is best performed reopening the previous surgical incision performed to insert the reservoir into the subcutaneous pocket. The novel incision is carried out along the previous scar, after appropriate local infiltration with local anesthetics (ropivacaine or else). In case of tunneled ports, two incisions may be required—one over the reservoir and the other at the venipuncture site, where the catheter gets into the vein—if there are difficulties in catheter extraction. If the reservoir is partially or totally exposed, or if the skin is altered by inflammation or extravasation, a lozenge incision should be performed, so to remove the previous scar together with the pathologic tissue. In most cases, local anesthesia (10–15 mL or less) will be sufficient: sedation or general anesthesia may be required in children or in non-cooperative patients.

(5) Catheter extraction. Soon after the incision, the connection between reservoir and catheter should be identified, and then the catheter should be lifted up with the klemmer. After freeing the catheter from the connective sleeve that normally surrounds it in the subcutaneous tissue, the catheter must be slowly extracted from inside the sleeve. The catheter can be freed from the connective sleeve using gentle rubbing with gauze; in some cases, a longitudinal incision of the sleeve using a scalpel may be necessary, but care should be taken not to injure the underlying catheter. The catheter should always be inspected after removal, to rule out damages or ruptures and verify that the whole length of the catheter has been removed.

In some situations, resistance to catheter extraction may be encountered, for several reasons:

- presence of a particularly thick connective sleeve in the subcutaneous tract (this event is more common in the case of chest ports);
- presence of a fibroblastic sleeve in the intravascular tract that, by coiling around the catheter during removal, increases the resistance at extraction (more frequent in the case of PICC-ports);
- presence of a granuloma at the site of catheter insertion into the vein (more frequent when the catheter has been inserted by "high" puncture of the internal jugular vein or by blind infraclavicular puncture of the subclavian vein, and particularly if the catheter is made of silicone).[12,20]

If the resistance at catheter extraction is due to fibroblastic sleeve, the catheter should be interrupted close to the connection with the reservoir and a metal guidewire should be threaded into the catheter; after this maneuver, the catheter will be more rigid and it will be easier to free it from the subcutaneous connective sleeve.[31,32] Also, if the resistance to extraction is due to the intravascular fibroblastic sleeve,[33] the guidewire inside the catheter will allow the catheter to be pulled out by imparting a rotational movement on its axis that will facilitate the rupture of the adherence between sleeve and catheter, as well as between sleeve and vein wall.[1] In some case reports, the presence of catheter-related thrombosis has also been described as a possible cause of difficult catheter extraction; though, it may be sometimes difficult to differentiate between thrombosis and fibroblastic sleeve. For example, in a recent case report,[34] the unsuccessful removal of a port was ascribed to thrombosis of the left brachiocephalic vein, but the angiographic images provided by the authors are strongly suggestive of a fibroblastic sleeve.

In the presence of a granuloma, the insertion of a metal guidewire inside the catheter is recommended too, since this will allow to follow more easily the tract of the catheter inside the subcutaneous tissues, till the site where the catheter enters the vein, that is, where the granuloma is located. Such granulomas are usually caused by the presence of microlesions of the catheter wall, either due to pinch-off (more frequently in case of silicone catheters) or due to excessive angulation of the catheter when entering the vein (lesions that are also more frequent with silicone catheters and particularly with Groshong® catheters, whose silicone is even more fragile).[12,20,24,35] In the abovementioned report of eight cases of "stuck" catheter during removal of 98 ports in children,[21] 90% of catheters had been inserted by blind infraclavicular approach and 70% of catheters were made of silicone. In the presence of particularly damaged or fragile catheters, the catheter may break during the removal and the distal fragment may be found to be stuck at its entrance in the vein or embolized inside the heart and the pulmonary circulation. In these situations, interventional cardiology or interventional radiology maneuvers will be necessary to retrieve the fragment, which may remain close the site of venipuncture or embolize more distally. According to the literature, embolization of catheter fragments has never been associated

with pulmonary ischemic damage. Though, there is a risk of arrhythmias, particularly if the fragment remains stuck inside the right ventricle.[36] The decision whether or not to remove the fragment and the urgency of the procedure depends on the actual clinical situation (presence of symptoms, location of the fragment, patient's prognosis, patient's willingness to consent to the maneuver).

The best prevention of such accidents involves proper strategies during port implantation:

- avoid silicone catheters (and especially Groshong® catheters, which are particularly fragile)[12,20,24,35];
- avoid "blind" subclavian puncture, an antiquate and dangerous technique that carries not only the risk of immediate complications (pneumothorax, arterial or nerve damage, etc.), but also the risk of late complications such as pinch-off[8,9,37];
- avoid "high" punctures of the internal jugular vein, which are associated with the risk of catheter kinking, which may cause damage of the catheter and granulomas secondary to leak of infused fluids.[8,12,37]

Routine culture of the tip of the catheter is not recommended, since it is not an accurate method for ruling out infectious complications; the proper diagnosis of port-related bloodstream infection is best established by paired blood cultures before removal, according to the method of differential time to positivity.[10]

(6) Removal of the reservoir. After extracting the catheter, the reservoir is removed. This maneuver is not associated with relevant risks, but it may be sometimes difficult, for example if a particularly thick capsule of connective tissue has developed around the reservoir, or if the reservoir has been placed far from the surgical incision or very deep inside the subcutaneous tissue, or if the reservoir has been sutured to the muscle (a practice now obsolete).

Removal of the reservoir should be done by blunt dissection; the scalpel should be used only to cut the skin. Removal of the reservoir is usually easier with PICC-ports than with chest-ports.

The currently recommended maneuver is to remove the reservoir while leaving the capsule in place, to avoid excessive tissue damage and local bleeding. Though, the strategy of leaving the capsule in place may have a late side effect, that is, the persistence of a seroma at the previous site of port removal. Such seroma is nothing else than the previous capsule, whose empty space has been occupied by serous fluid of lymphatic origin.

Formation of a hematoma at the site of removal is a rare occurrence, and it recognizes one of the following causes:

- failure to detect risk factors in the patient's history (e.g. low platelet-count patient or anticoagulant therapy);
- use of scissors or scalpel during the dissection;
- failure to suture arterial or venous vessels accidentally severed during the removal of the reservoir;
- presence of a particularly thick connective sleeve around the catheter, which may allow reflux of blood from the vein (if this occurs, the sleeve should be ligated soon after the extraction of the catheter);
- removal of the capsule surrounding the reservoir.

(7) Closure of the incision. Closure is best obtained by closing the derma with detached inverted stitches, using 3-0 or 4-0 adsorbable monofilament thread, and sealing the epidermis applying cyanoacrylate glue. The incision is then covered with gauze and semi-permeable transparent membrane, or with a transparent membrane alone. After a few days, the dressing is removed: a dry crust of cyanoacrylate glue will still be visible on the skin, but it should not be removed mechanically, since it will slowly flake off as the epidermal layers are replaced. A clean, uneventful closure of the incision will guarantee the possibility of reusing the same incision if implantation of a new TIVAD should be required in the following months or years. In case of infection, if there is purulent discharge inside the pocket, the secretion must be sent for culture; then, the wound must be rinsed, filled with gauze, and allowed to heal by second intention. In this case, peripheral blood culture might be indicated, if the patient has not yet started an antibiotic treatment. Delayed wound healing has been described as a possible but rare complication[24] and can be prevented by avoiding transcutaneous non-adsorbable sutures (which are potentially associated with infectious granulomas and wound dehiscence) and by proper suture of the derma followed by application of cyanoacrylate glue.

Conclusions

Complications during port removal are rare but potentially relevant, and they include bleeding, difficult or impossible removal of the catheter, embolization of catheter fragments into the circulation, infection, wound dehiscence, and seroma.

As suggested in a recent retrospective study,[24] a comprehensive pre-removal evaluation and the strict adherence to a well-defined procedural protocol of removal may effectively anticipate difficulty in removal and prevent complications.

Table 1. The SaRePo protocol.

Steps	Recommendations
1. Patient's history	Check for coagulation abnormalities or anticoagulant treatment. Collect information on port insertion: anticipate difficulties of extraction for very long indwelling device, silicone catheters, blind puncture of the subclavian vein, high puncture of the internal jugular vein.
2. Pre-procedural ultrasound scan	Check the integrity of the catheter and the location of the tip. Rule out venous thrombosis and fibroblastic sleeve.
3. Aseptic technique	Surgical hygiene of the hands, skin antisepsis with 2% chlorhexidine in 70% iso-propylic-alcohol, and "minimal" barrier precautions.
4. Incision	Re-open the previous incision, after proper infiltration with local anesthetic.
5. Catheter extraction	Remove the catheter first. Insert guidewire into the catheter, in case of resistance to extraction. Examine the catheter after removal.
6. Port removal	Remove the reservoir only after catheter extraction. Do not routinely remove the capsule that surrounds the reservoir.
7. Closure	Close with adsorbable intradermal suture and apply cyanoacrylate glue. Leave the wound open in presence of suppurative infection.

The SaRePo protocol developed by GAVeCeLT and described in this editorial includes seven steps (see Table 1) that may be helpful in this regard, if used as procedural checklist. Though, it is important to acknowledge that the prevention of removal-related complications relies also in the adherence to the current recommendations about port insertion and port maintenance. Current evidence-based recommendations[3,8,9,37] strongly discourage (a) the blind infraclavicular puncture the subclavian vein, (b) the "high" puncture of the internal jugular at mid neck, (c) the use of silicone catheters, and (d) the prolonged maintenance of ports that are not bound to be used any more. Avoidance of these four antiquate and inappropriate strategies is likely to be associated with a dramatic decrease in the incidence of adverse events during port removal.

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References

1. Dupont C and Kriegel I. *Guide pratique des chambres à cathéter implantables*. Lamarre Edition, Paris, 2019.
2. Pittiruti M and Pinelli F. *Manuale GAVeCeLT Dei Port*. EDRA, Milano, 2024.
3. Jahanzeb M, Wu CY, Lim H, et al. International experts consensus on optimal central vascular access device selection and management for patients with cancer. *J Vasc Access*. Epub ahead of print 2 December 2024. DOI: 10.1177/11297298241300792.
4. van Rens MR, van der Lee R, Spencer TR, et al. The NAVIGATE project: a GloVANet-WoCoVA position statement on the nomenclature for vascular access devices. *J Vasc Access*. Epub ahead of print 24 October 2024. DOI: 10.1177/11297298241291248.
5. Bertoglio S, Annetta MG, Brescia F, et al. A multicenter retrospective study on 4480 implanted PICC-ports: a GAVeCeLT project. *J Vasc Access*. Epub ahead of print 17 January 2022. DOI: 10.1177/11297298211067683.
6. Annetta MG, Ostroff M, Marche B, et al. Chest-to-arm tunneling: a novel technique for medium/long term venous access devices. *J Vasc Access* 2023; 24(1): 92–98.
7. Annetta MG, Marche B, Ortiz Miluy G, et al. Totally implanted central venous access devices inserted by the femoral route: a narrative review and the proposal of a novel approach, the FICC-port. *J Vasc Access*. Epub ahead of print 6 May 2024. DOI: 10.1177/11297298241236816.
8. Pittiruti M and Scoppettuolo G. Raccomandazioni GAVeCeLT, https://www.gavecelt.it/nuovo/sites/default/files/uploads/raccomandazioni-gavecelt-2024.pdf (2024, accessed January 2024).
9. Nickel B, Gorski L, Kleidon T, et al. Infusion therapy standards of practice, 9th edition. *J Infus Nurs* 2024; 47(1S Suppl 1): S1–S285.
10. Chaves F, Garnacho-Montero J, Del Pozo JL, et al. Diagnosis and treatment of catheter-related bloodstream infection: clinical guidelines of the Spanish Society of Infectious Diseases and Clinical Microbiology and (SEIMC) and the Spanish Society of Spanish Society of Intensive and Critical Care Medicine and Coronary Units (SEMICYUC). *Med Intensiva* 2018; 42(1): 5–36.

11. Brescia F, Pittiruti M, Scoppettuolo G, et al. Taurolidine lock in the treatment of colonization and infection of totally implanted venous access devices in cancer patients. *J Vasc Access* 2023; 24(1): 87–91.
12. Balsorano P, Galducci G, De Fanti I, et al. Fractures of totally implantable central venous ports: more than fortuity. A three-year single center experience. *J Vasc Access* 2014; 15(5): 391–395.
13. Kılıç S, Soyer T, Karnak İ, et al. Evaluation of the removal reasons of totally implantable venous devices in children: a retrospective study. *Turk J Pediatr* 2016; 58(2): 187–194.
14. Thiel K, Kalmbach S, Maier G, et al. Standardized procedure prevents perioperative and early complications in totally implantable venous-access ports—a complication analysis of more than 1000 TIVAP implantations. *Langenbecks Arch Surg* 2022; 407: 3755–3762.
15. Gennequin M, Elmawieh J and Gomas F. Complications after removal of totally implanted central venous access devices: a single-center retrospective study. *J Vasc Access* 2024; 25(4): 1219–1223.
16. Liu S, Nataraja RM, Lynch A, et al. Incidence and risk factors of complications during central venous access devices removal in children. *J Vasc Access*. Epub ahead of print 3 August 2024. DOI: 10.1177/11297298241260899.
17. Diamantidis D, Papatheodorou N, Perente S, et al. Asymptomatic spontaneous migration of the tip of Port-a-Cath system into the right internal jugular vein: a case report of an uncommon complication. *Cureus* 2022; 14(7): e26937.
18. D'Arrigo S, Annetta MG, Musarò A, et al. Secondary malposition of a PICC-port due to heavy physical exercise: a case report. *J Vasc Access* 2023; 24(3): 507–510.
19. Papatheodorou N, Sr Argyriou C, Botaitis S, et al. Endovascular retrieval of a detached and dislocated venous port catheter in the right heart chamber using a triple-loop snare device. *Cureus* 2023; 15(1): e33681.
20. Chatani S, Tsukii R, Nagasawa K, et al. Difficult removal of totally implantable venous access devices in adult patients: incidence, risk factors, and management. *J Vasc Access* 2023; 24(5): 1150–1157.
21. Jung H, Cho JY, Seok Y, et al. Stuck fragment of totally implantable central venous access ports during removal: risk factor analysis in children. *BMC Surg* 2021; 21(1): 276.
22. Teague WJ, Fouad D, Munro FD, et al. Complicated vascular access port removals: incidence, antecedents and avoidance. *Pediatr Surg Int* 2015; 31(9): 859–864.
23. Aworanti OM, Linnane N, Tareen F, et al. Incidence and outcome of retained Port-A-Cath fragments during removal. *Pediatr Surg Int* 2017; 33(7): 777–781.
24. Su J, Liu L, Xie Y, et al. Complications associated with the removal of totally implantable venous access devices (TIVADs): a retrospective analysis of 4,954 breast cancer patients in a single institution. *BMC Surg* 2024; 24(1): 324.
25. 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.
26. Brescia F, Pittiruti M, Ostroff M, et al. The SIC protocol: a seven-step strategy to minimize complications potentially related to the insertion of centrally inserted central catheters. *J Vasc Access* 2023; 24: 185–190.
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: 527–534.
28. 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.
29. Brescia F, Annetta MG, Pinelli F, et al. A GAVeCeLT bundle for PICC-port insertion: the SIP-Port protocol. *J Vasc Access* 2024; 25(6): 1713–1720.
30. D'Arrigo S, Annetta MG and Pittiruti M. An ultrasound-based technique in the management of totally implantable venous access devices with persistent withdrawal occlusion. *J Vasc Access* 2023; 24(1): 140–144.
31. Awan MY, Almatar Z, AlShawa MA, et al. Difficult removal of implantable venous access system: stepladder approach with wire stenting of a catheter—single-center experience. *Ann Pediatr Surg* 2023; 19: 23.
32. Ding JY, Li L, Fu XR, et al. A stepwise interventional strategy for the removal of adherent totally implanted central venous access port catheters. *Ann Vasc Surg* 2024; 106: 162–167.
33. Passaro G, Pittiruti M and La Greca A. The fibroblastic sleeve, the neglected complication of venous access devices: a narrative review. *J Vasc Access* 2021; 22(5): 801–813.
34. Zhang X and Geng C. Unsuccessful removal of a totally implantable venous access port caused by thrombosis in the left brachiocephalic vein: a case report. *Medicine (Baltimore)* 2019; 98(13): e14985.
35. Tang TT, Li YT, Zhang LN, et al. Handling measures for the implantable vascular access device to prevent of catheter fracture/disruption. *Int J Clin Exp Med* 2016; 9(2): 3191–3196.
36. Awan A, Ahsan B, Iftikhar H, et al. Supraventricular tachycardia and tricuspid regurgitation in the setting of misplaced implantable port catheter tip. *Cureus* 2017; 9(7): e1460.
37. 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(5): 344–376. Erratum in: Eur J Anaesthesiol. 2020 Jul;37(7):623.