Review Article

Formosan Journal of Surgery

OPEN

Port-A catheter complications: Incidence, risk factors, prevention, and management

Ching-Hua Tsai[a], Hang-Tsung Liu[a], Ching-Hua Hsieh[b,*]

Abstract

Port-A catheters (totally implantable venous access devices) are essential for long-term central venous access in patients requiring chemotherapy, parenteral nutrition, or prolonged therapy. Although offering improved quality of life compared with external catheters, these devices have complication rates ranging from 1% to 20%. This comprehensive review details major Port-A complications, including infectious, thrombotic, mechanical, and malpositioning complications. Infections (2%–20% incidence) include port-pocket infections and catheter-related bloodstream infections, with risk factors including hematologic malignancies and neutropenia. Thrombotic complications (3%–8%) can affect device function and patient outcomes, whereas mechanical complications (1%–10%) include insertion-related trauma, pinch-off syndrome, and catheter fractures. Malpositioning complications occur initially or as a secondary migration, potentially causing extravasation or thrombosis. Management strategies range from conservative approaches to device removal, with most complications showing favorable outcomes when properly addressed. Our findings revealed that early detection, proper insertion techniques, and standardized management protocols can significantly improve outcomes, highlighting the importance of multidisciplinary care in maximizing device benefits while minimizing risks.

Keywords: Catheter-related bloodstream infections; Catheter-related complications; Catheter-related thrombosis; Port-A catheter; Totally implantable venous access device (TIVAD)

1. Introduction

Port-A catheters, also known as totally implantable venous access devices (TIVADs), provide long-term central venous access to patients requiring chemotherapy, parenteral nutrition, or other prolonged therapies.[1,2] These devices comprise a subcutaneous reservoir connected to a catheter that terminates in the central vein, typically the superior vena cava.[1] Compared with externally tunneled catheters or peripherally inserted central catheters, ports offer improved patient quality of life and typically lower infection risk owing to their fully implanted design.[3] However, Port-A systems are not without complications, with overall rates ranging from 1% to 20% across studies,[1,4] reflecting differences in definitions, patient populations, and follow-up durations.

This review provides a comprehensive overview of Port-A–related complications, summarizing the incidence (Table 1), risk factors (Table 2), preventive measures, management strategies (Table 3), and outcomes associated with each major category: infectious, thrombotic, mechanical, and malpositioning complications (Fig. 1).

[a]Department of Trauma Surgery, Kaohsiung Chang Gung Memorial Hospital and Chang Gung University College of Medicine, Kaohsiung, Taiwan, [b]Department of Plastic Surgery, Kaohsiung Chang Gung Memorial Hospital and Chang Gung University College of Medicine, Kaohsiung, Taiwan

*Corresponding author. Address: Department of Plastic Surgery, Kaohsiung Chang Gung Memorial Hospital and Chang Gung University College of Medicine, Kaohsiung 83301, Taiwan. E-mail address: m93chinghua@gmail.com (C.-H. Hsieh).

Formosan Journal of Surgery (2026) 59:3

Received: 15 October 2025; Accepted: 23 November 2025

Published online: 9 December 2025

http://dx.doi.org/10.1097/FS9.0000000000000264

2. Infectious complications

2.1. Incidence and types

Infection is a major Port-A complication.[5] Reported infection rates range widely from 2%–3% in some series and over 20% in high-risk populations.[5] Large contemporary cohorts typically report infection rates in the single digits, with approximately 6.9% developing a port-related infection within 1 year,[5] and approximately 2%–5% of ports eventually requiring removal because of infection.[6,7]

Infections may involve the port pocket (local cellulitis or an abscess at the reservoir site) or manifest as catheter-related bloodstream infections (CRBSIs) originating from the port. The most common causative organisms are skin flora, such as Staphylococcus species (including *Staphylococcus aureus* and coagulase-negative staphylococci).[7] Candida species are also frequently encountered, particularly in immunosuppressed patients.[7] Gram-negative bacteria are less common but can occur, particularly in children with febrile neutropenia and chemo-port infections.[8]

Infectious complications can be categorized as early infections, occurring within days to weeks of insertion (typically related to insertion site contamination), and late infections, occurring months later (often from hub contamination during access or hematogenous seeding). Port-pocket infections usually present with local swelling, erythema, tenderness, or drainage at the port site, whereas CRBSIs present with fever, chills, and bacteremia in the absence of another source.[2,3] Infections are a major cause of TIVAD failure. Studies indicate that infection is the single most common reason for port removal, accounting for approximately 46%–81% of all port removals in some series.[7,9]

Table 1

Complication Rates in Selected Port-A Studies (Last 10 Years)

Study and Population	Sample Size	Overall Rate	Infectious	Thrombotic	Mechanical	Malposition
Jung et al.[33]—Surgical placement	172	14.0% overall; Internal Jugular: 8.7%; Subclavian: 20.3%	4.7%	2.9%	4.1% pinch-off/ malfunction, 0.6% pneumothorax	2.3% catheter migration/ malposition
Skelton et al.[5]—Oncology patients	539	18.6% had ≥1 complication	6.9%	7.2% VTE	3.7% mechanical failure, 1.0% extravasation	2.0% catheter migration, 0.2% pneumothorax
Sharma and Pandey[16]—Cancer patients	119	31.9% overall; Early (<30 days): 11.8%; Late: 24.4%	7.5% port infections	3.3% symptomatic thrombosis	2.5% wound dehiscence, 0.8% port rotation, 0.8% skin necrosis	9.2% tip malposition (intra-op), 5.0% post-op extravasation
Kim et al.[4]—Mixed cancer (interventional radiology placement)	843	4.0% overall	1.4% total infection (<1% pocket; 0.8% catheter-related)	0.5% catheter-associated thrombosis	1.0% catheter migration, 0.7% pocket erosion	0.3% chamber malposition
Kakkos et al.[6]—All-comers, prospective	4045	7.2% required port removal due to complications	2.5% required removal for infection	Not reported separately	1.0% port-pocket expulsion	Not given precisely

VTE, venous thromboembolism.

2.2. Risk factors

Certain patient and treatment factors predispose Port-A devices to infection. Underlying hematologic malignancies pose a particularly high risk. Patients with leukemia or lymphoma often experience intensive chemotherapy and prolonged neutropenia, which significantly increases the risk of infection.[7] A previous study involving a large sample size showed that having a hematologic cancer was associated with an eightfold higher odds of developing a port infection (odds ratio [OR] ≈7.8) compared with having a solid tumor.[7]

Similarly, patients receiving palliative chemotherapy (advanced disease) had approximately five times higher odds of infection than those receiving adjuvant or curative regimens,[7] likely reflecting immunosuppression and cumulative exposure to sicker patients. Chemotherapy-induced neutropenia is a key driver; ports used for regimens with a high risk of neutropenia have significantly more infections. Kakkos et al.[6] found that intermediate/high neutropenia-inducing chemotherapy regimens were associated with a 9.4% port complication removal rate versus 5.5% for low-risk regimens (P = 0.003), mostly because of infection.

Additional risk factors include inpatient placement or access; patients whose ports are inserted or heavily accessed during hospital stays have higher infection rates than those whose ports are placed and managed entirely outpatient.[7] Device or technical factors can also play a role, including double-lumen ports (rarely used) or ports with frequent access, although standard single-lumen chest ports that are accessed intermittently have relatively low infection rates if properly maintained.[3] Failure to maintain strict sterile technique during insertion or access increases the risk of complications, as does poor wound healing at the port site, particularly in patients receiving corticosteroids or bevacizumab therapy.[10–12]

Table 2

Key Risk Factors for Port-A Complications

Complication Type	Identified Risk Factors
Infectious	• Hematologic malignancy: significantly higher infection risk[7] • High neutropenia chemotherapy regimens[6] • Advanced cancer/palliative care: immunosuppression[7] • Inpatient placement or frequent hospital access[7] • Poor sterile technique[3] • Impaired healing/skin integrity: steroids, bevacizumab[16] • Chronic illnesses: diabetes, renal failure[47,48]
Thrombotic	• Prior history of DVT/PE: doubles risk[23] • Left-sided or subclavian placement: subclavian has ~2× higher risk[23] • Catheter tip in suboptimal location has ~1.9× higher risk[23] • Hypercoagulable state: active cancer, high Khorana score[27] • Obesity[27] • Hormonal therapy: tamoxifen[27] • Lack of anticoagulation in high-risk settings[31,32]
Mechanical	• Subclavian vein access: higher risk of pneumothorax and pinch-off[31,32] • No imaging guidance increases risk of complications[31,32] • Operator inexperience[4] • Challenging patient anatomy[49,50] • High activity or trauma postplacement[51,52] • Inadequate port securing[51,53] • Early port use (<5–7 days)[6] • Medications affecting healing: bevacizumab, steroids[16]
Malpositioning	• Left-sided placements: more complex vascular anatomy[5] • Absent intraoperative imaging[1,54] • Preexisting venous stenosis[55,56] • Guidewire technical factors[57,58] • Patient movement during placement[59] • Small diameter veins[60,61]

DVT, deep vein thrombosis; PE, pulmonary embolism; SVC, superior vena cava.

2.3. Prevention

Preventive strategies should focus on sterile techniques and appropriate catheter care. A strict aseptic protocol during port implantation is critical, including full-barrier precautions (gown, gloves, drapes, and mask) for the operator and the patient, chlorhexidine skin antisepsis, and prophylactic measures similar to those used for central line insertion.[3] Imaging guidance (ultrasound for venous access and fluoroscopy for catheter placement) helps prevent multiple failed attempts or malpositions that could indirectly increase the risk.[4]

Routine use of antibiotic prophylaxis before port placement is not generally recommended. In a large series of 1747 port insertions performed without prophylactic antibiotics, the infection rate was only 2.3%.[7] During port access, a strict sterile technique is vital: the port site should be disinfected, and only noncoring Huber needles should be used. Some institutions use antimicrobials or heparin-lock solutions to prevent biofilm formation. Patient education also plays a role; patients and caregivers should be educated on recognizing signs of infection early and keeping the port site clean and dry when not accessed.

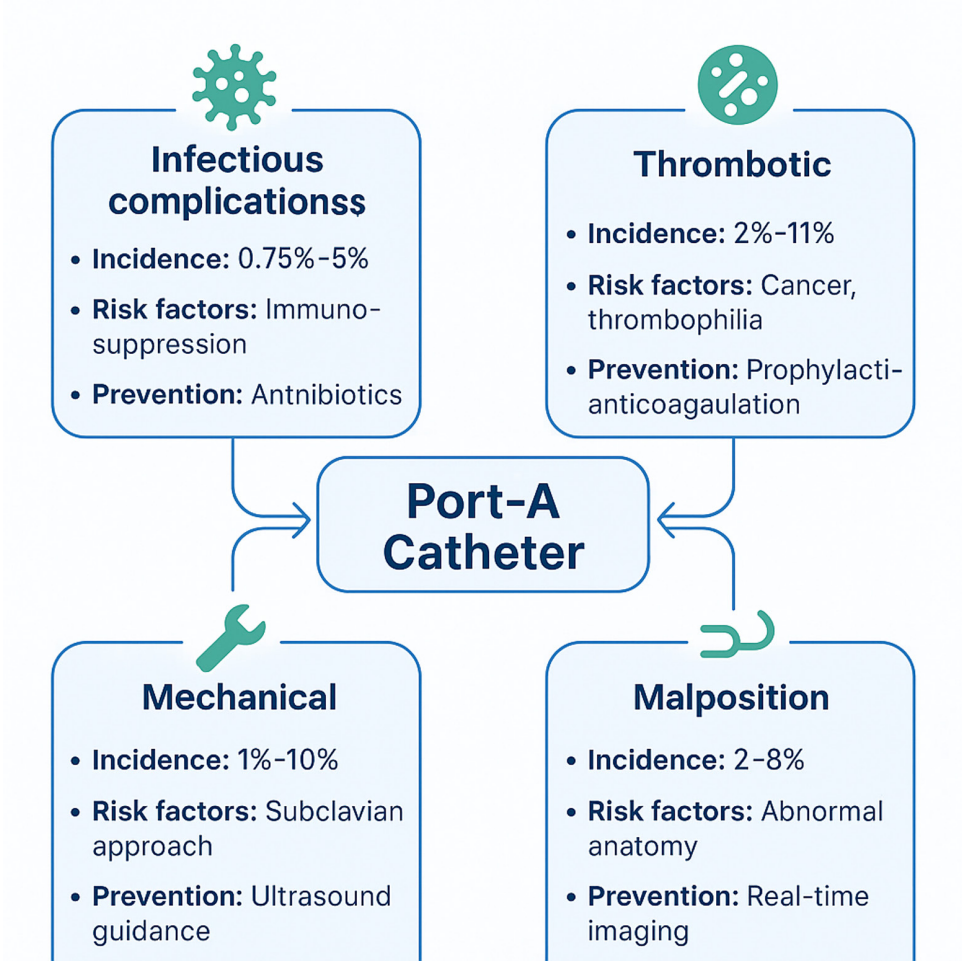

Figure 1. The diagram's center shows a Port-A catheter, with four branches detailing complication types: infection (depicted by a microbe icon, with incidence ranges noted); thrombosis (clot icon, highlighting risk factors such as active malignancy and chemotherapy); mechanical issues (gear icon illustrating pinch-off, fracture or occlusion, noting subclavian insertion as higher risk); and malposition or migration (compass icon identifying misplacement into the internal jugular, mammary or azygos veins and causes like coughing). Together, these elements emphasize comprehensive awareness of port-related complications.

2.4. Management

When port-related infections are suspected, prompt evaluation and intervention are required to prevent serious sequelae. Management depends on the severity and type of the infection.

1. Superficial port-pocket infections (erythema without systemic signs) can sometimes be managed using empiric antibiotics with close observation, provided there is no abscess and the device appears intact.[4] If there is abscess formation or if the local infection does not improve quickly with antibiotics, the port should be removed to clear the infection source.[9]
2. Confirmed CRBSIs or port sepsis typically warrant systemic antibiotic therapy and port removal, especially for virulent organisms. Removal of the port is generally indicated for *S. aureus*, Pseudomonas, Candida, or any infection causing sepsis,[3] because these organisms can adhere to the catheter and form biofilms that are difficult to fully eradicate.[13] In a prospective study in France, 81% of port infections ultimately required device removal for cure.[9]
3. For less virulent infections, such as coagulase-negative staphylococci, which are common skin contaminants, a more conservative approach may be attempted if the port is crucial (eg, no other good venous access). This involves a combination of systemic antibiotics and antibiotic lock therapy (ALT). Studies have shown that ALT can be used to salvage a significant proportion of infected ports. For instance, a study reported a 75% success rate in clearing Staphylococcus epidermidis port infections with ALT (only 1 of 60 patients had recurrence).[14] However, success rates vary widely (often 50%–80% for coagulase-negative staphylococci) and may decline substantially for more aggressive organisms.[3]

After an infected port is removed, a new port can be reimplanted once the infection has cleared (usually after an appropriate antibiotic course and confirmation of negative cultures). Clinicians often wait approximately 7–14 days after the last positive culture before placing a new device, possibly on the opposite side. If an infection is caused by *S. aureus* or yeast, some guidelines recommend a longer delay and ensure at least 4–6 weeks of effective therapy to prevent relapse.[3]

2.5. Outcomes

Most port infections resolve without long-term sequelae with prompt treatment. However, infectious complications can significantly disrupt therapy (owing to hospitalization and loss of venous access) and can be life-threatening if not managed properly.[5] The infection-related mortality rate is not trivial; for example, in a study involving oncology patients, eight patients (1.5% of the cohort) died due to port complications, predominantly from sepsis.[5]

Table 3

Management Strategies for Port-A Complications

Complication	Primary Management	Typical Outcomes
Port infection	• Systemic antibiotics targeting likely organisms • Remove port for severe infections or abscesses • Antibiotic lock therapy with systemic antibiotics for select cases • Local wound care for superficial infections	Resolution with appropriate therapy; ALT salvages ~50%–75% of mild CRBSIs.[8] Device removal leads to cure in most cases.[7] Hospitalization is often required, delay in treatment. Low mortality if managed promptly.[3]
Thrombosis	• Therapeutic anticoagulation for ≥3 months • Keep port if functional • Thrombolysis for massive symptomatic clots • tPA for intraluminal clots	Improvement within days; clot resolution by 3 months in most cases. Port often preserved.[11] Recurrence uncommon on therapy (≤5%).[11] Reduced PE risk once anticoagulation started.
Mechanical complications (early)	• Arterial puncture: compression • Pneumothorax: chest tube if large/symptomatic • Hemothorax: drainage; possible surgical intervention • Air embolism: Durant's maneuver, supportive care • Misplaced catheter: immediate repositioning	Usually full recovery. Pneumothorax resolves after chest tube. Arterial injuries rarely cause lasting issues if promptly managed. New port attempt can be made after resolution. Insertion-related deaths are extremely rare.
Mechanical complications (late)	• Pinch-off: port revision via different route • Catheter fracture: retrieval by interventional radiology • Occlusion: contrast study, possible surgical correction • Port rotation: reposition and secure • Extrusion/dehiscence: remove port, treat wound • Extravasation: stop infusion, apply antidote if available	Outcomes vary by issue. When addressed promptly, most resolve without lasting damage. Fracture retrieval has high success.[1] Occlusions often resolved with tPA or revision. Port rotations can be fixed immediately. Extrusion requires removal but new port possible later. Extravasation outcomes depend on drug and intervention timing.
Malposition	• Do not use until corrected • Interventional radiology guided repositioning or surgical correction • Remove and replace if migration out of vein • Verify correct position after adjustment	Proper position is usually achievable with minor intervention. Once corrected, port functions normally. If left malpositioned, risks include ineffective treatment, thrombosis, or local damage. Outcomes depend on timely detection.

ALT, antibiotic lock therapy; CRBSI, catheter-related bloodstream infection; PE, pulmonary embolism; tPA, tissue plasminogen activator.

S. aureus port infections carry risks of endocarditis and metastatic infections (including vertebral osteomyelitis), underscoring the need for aggressive management. Port-pocket infections, if neglected, can progress to chest wall necrosis or systemic infection.[15] On the positive note, studies indicate that if a port infection is appropriately managed, patients can usually resume the required therapy with either a new port or alternative access once the infection is cleared.

3. Thrombotic complications

3.1. Incidence and presentation

Thrombotic complications refer to the formation of clots associated with the port catheters. These include catheter-related thrombosis (CRT), which is usually a thrombosis of the vein in which the catheter resides (such as the subclavian vein, internal jugular vein, or superior vena cava), as well as intraluminal clots or fibrin sheaths that occlude the catheter.

The incidence of symptomatic CRT in Port-A patients with Port-A access varies but is a significant concern. In general oncology populations, approximately 3%–8% of patients develop clinically evident venous thrombosis related to their port.[5] For example, Skelton et al.[5] reported a 7.2% incidence of port-associated venous thromboembolism (VTE; upper extremity deep vein thrombosis [DVT] or pulmonary embolism [PE]) within 1 year, and Sharma and Pandey[16] observed a 3.3% rate of symptomatic thrombosis over ~3 years. Some studies that performed routine ultrasound have found higher rates of subclinical thrombosis, up to 73%,[17] but most asymptomatic clots remain undetected and may resolve or remain clinically insignificant.[18,19]

Patients with port-related thrombosis may present with swelling, pain, or edema of the neck, face, or ipsilateral arm due to venous outflow obstruction. They may have noted distending collateral veins in the chest or arm. If the superior vena cava is involved, more dramatic head/neck venous congestion can occur, similar to the superior vena cava syndrome, although this is uncommon with ports.[20] Occasionally, the first sign of CRT is difficulty in flushing the port or an inability to draw blood. Port-related clots can also embolize; a portion of the clots may break off and travel to the lungs, causing PE.[21,22]

3.2. Risk factors

Many risk factors for CRT overlap with general VTE risk factors as well as specific device-related factors. Patients with cancer are generally hypercoagulable; however, certain factors can increase the likelihood of a port-causing thrombosis.

1. History of thrombosis: Patients with a history of DVT or PE have approximately double the risk of developing catheter-related clots. A large meta-analysis found that prior DVT conferred an OR of ~2.0 for CRT in patients with cancer.[23,24]
2. Site and technique of catheter insertion: The choice of vein and insertion method can influence the risk of thrombosis. Subclavian vein access (particularly via venipuncture under the clavicle) is associated with higher thrombosis rates than internal jugular access.[23] In a meta-analysis of 5636 patients, subclavian puncture was an independent risk factor (OR = 2.16) for CRT compared with other approaches.[23] Some studies have observed a higher incidence of thrombosis when the port is placed on the left side than on the right side, presumably because left-sided catheters traverse the left innominate vein, which has a more angulated route into the superior vena cava.[5,25,26]
3. Catheter tip position: An improper tip location is a well-documented risk factor for thrombosis. Ideally, the catheter tip should lie at the cavoatrial junction of the superior vena cava and the right atrium.[1] If the tip is too high or pointed upward in a small vein, blood flow around the catheter is less brisk, and stasis can occur, promoting clotting. In a meta-analysis, Saber et al.[23] reported that malpositioned catheter tips were associated with an approximately 1.9-fold increased odds of CRT.

4. Patient-related factors: The general prothrombotic risk profile of patients plays an important role. Patients with certain malignancies (including pancreatic, gastric, and brain cancers) have an inherently higher risk of developing a VTE. Obesity is another contributor; 73% of patients who developed port thrombosis in one study were overweight or obese,[27] suggesting that elevated body mass index may predispose patients to CRT. Other factors include comorbidities, immobility, recent surgery, and use of certain chemotherapeutic agents or hormonal therapies (such as tamoxifen or estrogen).[28–30]

3.3. Prevention

Preventing CRT is challenging because patients with cancer are inherently at risk and ports must reside in the central veins. However, several measures can mitigate this risk.

1. Optimal vein and tip placement: Using the internal jugular vein or a more lateral approach to the subclavian vein (to avoid pinch-off) may reduce the risk of endothelial injury and stasis. Imaging guidance ensures that the catheter tip is placed in the high-flow distal superior vena cava/right atrium region,[1] which helps to prevent thrombus formation on the tip.
2. Routine flushes and locking: Maintaining catheter patency with regular flushes may help prevent fibrin buildup. The standard practice is to flush the ports with saline (10–20 mL) after each use and lock the port with saline or heparin.
3. Avoiding routine prophylactic anticoagulation: Clinical trials and guidelines, including those from the American Society of Clinical Oncology and National Comprehensive Cancer Network, indicate that routine thromboprophylaxis in patients with cancer with central lines offers no clear net benefit and poses bleeding risks.[31,32] Instead, prophylaxis is reserved for patients with additional VTE risk factors or certain high-risk malignancies, where the benefits outweigh the risks.
4. Patient risk modification: If feasible, weight reduction in obese patients, good hydration, and maintenance of the patient as ambulatory as much as possible may reduce stasis. If a patient has known thrombophilia or a history of clots, a prophylactic dose of an anticoagulant is sometimes considered on a case-by-case basis.

3.4. Management

When port-associated thrombosis is confirmed (by Doppler ultrasound or venography), anticoagulation is the cornerstone of treatment. The current practice for cancer-associated CRT is to initiate therapeutic dose anticoagulation, typically with low-molecular-weight heparin or direct oral anticoagulants (DOACs), such as apixaban or rivaroxaban, unless contraindicated.[27] The standard duration of anticoagulation therapy is at least 3 months.[27]

If the port is still required and is functional, it is often left in place during anticoagulation therapy. Studies have indicated that many catheter-related clots resolve or stabilize with anticoagulation even if the catheter remains in situ.[27] For example, in Dridi's analysis of 33 port thrombosis cases, only three ports were removed because of nonfunctionality and two for infection, while the rest were treated without port removal.[27]

If the catheter is completely occluded by a thrombus (unable to flush) and is needed for ongoing therapy, one approach is to attempt clearance using thrombolytic agents (including alteplase). For extensive clots causing severe symptoms (such as the superior vena cava syndrome or significant arm swelling), catheter-directed thrombolysis or mechanical thrombectomy can be considered, although these invasive interventions are generally reserved for acute symptomatic thromboses where rapid relief is needed.

Port removal is not usually mandatory for thrombosis. If the port is functioning and not infected, the guidelines often suggest continuing anticoagulation with the catheter in place.[27] The port might be removed if the thrombus occludes the catheter, making it unusable, if the patient's therapy is completed, or if the patient develops recurrent thrombosis despite anticoagulation.

3.5. Outcomes

The prognosis of CRT is generally favorable after treatment. Most patients' symptoms improve within a few weeks of anticoagulation treatment, and they do not experience recurrence as long as the catheter is in a good position and they remain on therapy. In a study by Dridi et al.,[27] only 1 of 33 patients (3%) had a recurrence of thrombosis after therapy, and a few (three patients) developed infections during or after therapy.

A potential long-term complication is postthrombotic syndrome in the arm, characterized by chronic swelling and discomfort from venous damage, although it occurs less frequently in arm veins than in leg DVTs. A serious outcome that should be avoided is PE. Fortunately, fatal PE due to upper extremity catheter thrombosis is relatively rare. The overall mortality attributable to port-related thrombosis is low, and deaths from port complications are much more likely due to infection than thrombosis.[5]

Another outcome to consider is the loss of venous access; a thrombosed vein may preclude the future use of that vein for another catheter. Thus, preventing thrombosis has the benefit of preserving venous patency for future access.

4. Mechanical complications

4.1. Definition and incidence

Mechanical complications encompass a broad category of noninfectious and nonthrombotic issues related to port hardware or placement. These can be subclassified into early (periprocedural) mechanical complications, which typically occur at the time of insertion or soon after, and late mechanical complications, which occur during long-term use.

Mechanical complications account for 1%–10% of ports and encompass insertion trauma, pinch-off syndrome, catheter fracture and embolization, nonthrombotic occlusion, port rotation, pocket problems, extravasation, and cardiac arrhythmias. Subclavian access increases the risk of pinch-off and catheter fracture compared with the internal jugular route, and extra-anatomic tunneling predisposes patients to chamber rotation. Jung et al.[33] found that approximately 8.1% of ports had a mechanical issue (excluding infection/thrombosis), with a significantly higher incidence in subclavian versus internal jugular placements. Skelton et al.[5] noted approximately 3.7% with mechanical failure (eg, occlusion requiring Tissue Plasminogen Activator or port replacement), an additional 2% with catheter migration, and 1% with extravasation.

4.2. Types of mechanical complications

1. Insertion-related trauma: This includes accidental arterial puncture, hematoma formation, pneumothorax, hemothorax, air embolism, and nerve injury. Serious insertion complications are infrequent with modern techniques; pneumothorax occurs in approximately 0.5%–3% of subclavian vein access attempts[33]; but with ultrasound

guidance, the incidence is much lower. In Jung et al.'s[33] series, there was one pneumothorax (0.6%) in 172 placements.
2. Port malposition or misplacement: This refers to the catheter tip ending in an improper location upon insertion, such as the ipsilateral internal jugular vein, contralateral subclavian vein, or azygos vein. Malposition is reported in up to 5%–6% of cases when not using intraoperative imaging.[1] Proper imaging during placement has reduced this dramatically, as some series report <1% malpositioning when fluoroscopy is used.[1]
3. Pinch-off syndrome: This occurs when a port catheter, inserted via the subclavian vein, is pinched between the clavicle and first rib in the costoclavicular space.[1] Over time, the repetitive clavicular movements can compress and damage the catheter. Jung et al.[33] reported pinch-off syndrome in 2.3% of subclavian-approach ports, and none of the internal jugular approaches. If left undetected, pinch-off can lead to catheter fracture and embolization.
4. Catheter fracture and embolization: A port catheter can fracture owing to material fatigue or pinch-off. When a fracture occurs, a portion of the catheter embolizes into the venous circulation. Often, the fragment travels to the right side of the heart or pulmonary arteries. Although rare (<1%), cases have been reported in which fractured catheter segments migrated to the heart.[1]
5. Catheter occlusion (nonthrombotic): Not all occlusions are due to thrombosis, and some are mechanical. For example, a kinked catheter can obstruct flow, or port chamber issues can cause occlusion if the septum is damaged.
6. Port chamber rotation or flip: The port reservoir is usually sutured to the chest wall or fascia. If not adequately secured, the port can rotate or flip upside-down in its pocket. Sharma and Pandey reported port rotation in 0.8% of cases.[16]
7. Port-pocket problems: These include wound dehiscence, where the incision reopens, and port extrusion, where the port works its way out of the body. In Sharma's study, 2.5% had wound dehiscence and 0.8% had skin necrosis, leading to exposure of the reservoir.[16] Kakkos et al.[6] noted port-pocket "expulsion" in approximately 1% of patients.
8. Extravasation of infusate: This means chemotherapy or fluid being infused leaks out of the intended vascular space into the surrounding tissue. With ports, extravasation can occur if the catheter is fractured or if the needle is incorrectly placed in the port septum. In Sharma et al.'s[16] study, drug extravasation occurred in 5% of patients.
9. Cardiac complications: Although rare, improper catheter positioning or migration can cause mechanical irritation to the heart. If the catheter extends too far into the right atrium, it can trigger cardiac arrhythmias.[34–36] There have been reports of port catheters causing cardiac tamponade due to perforation of the heart or the great vessels.[1]

4.3. Risk factors

Key factors for mechanical complications include the site of insertion. Subclavian access is associated with a higher risk of pneumothorax and pinch-off than internal jugular access.[33] Jung et al.[33] reported that all pinch-off cases were in the subclavian ports and none were in the internal jugular port, and overall mechanical complication-free survival was much better for the internal jugular approach. Lack of imaging guidance, operator inexperience, and patient factors such as body habitus, bevacizumab therapy, inadequate port fixation, and patient behavior (including excessive arm motion) can all contribute.

4.4. Prevention

Preventive measures for mechanical complications span the entire process of port placement and use:

1. Ultrasound-guided venous access reduces complications such as arterial puncture, hematoma, and pneumothorax[4]
2. Fluoroscopic guidance for catheter placement ensures the correct path to the superior vena cava and detects any malposition immediately[1]
3. Proper catheter routing and length to avoid pinch-off and excess slack[36,37]
4. Secure port anchoring and appropriate wound closure[30]
5. Avoid immediate use when possible (Kakkos et al.[6] demonstrated that waiting at least 6–7 days after placement before using the port significantly lowers complication-related removal)
6. Education on activity restrictions and proper access technique[38]
7. Regular maintenance protocols and flushing[39,40]

4.5. Management

The management of mechanical complications varies by type:

1. Insertion injuries: Pneumothorax may require a chest tube if it is large or symptomatic. Arterial puncture is performed by immediate removal of the needle and application of pressure.
2. Pinch-off syndrome: If recognized, management should involve removing and relocating the port catheter via a different route (often through the internal jugular vein) to prevent recurrence.
3. Fracture and embolization: Any embolized fragment should be retrieved by an interventional radiologist, usually using a gooseneck snare advanced through the femoral vein.[1]
4. Occlusions: For nonthrombotic occlusions, imaging can show whether there is a kink or disconnection. A kink may be corrected by repositioning, but port chamber issues, such as flipped ports or septum damage, require surgical correction.
5. Port-pocket complications: Wound dehiscence without infection can be managed by resuturing the wound. Port extrusion mandates port removal.
6. Extravasation: If suspected, stop the infusion immediately and follow extravasation protocols, including attempting to aspirate the residual drug, applying appropriate antidotes if available, and surgical consultation if necessary.

4.6. Outcomes

Most mechanical complications can be resolved with appropriate interventions. Early complications such as pneumothorax or arterial injury usually result in full recovery without long-term consequences, although they contribute to patient morbidity and may delay cancer treatment. Late mechanical issues often require device replacement. Owing to minimally invasive techniques, even serious events, such as catheter embolization, are often resolved via percutaneous snare retrieval, with a high success rate.[1] Mortality due to mechanical complications is extremely low, and large reviews indicate that these issues are not a significant direct cause of mortality.[5]

5. Malpositioning complications

Malpositioning refers to improper placement or migration of the tip of the catheter to an unintended location. Although this can

be considered a subset of mechanical complications, malposition is distinct in that the catheter itself remains intact, but is simply in the wrong place. Initial malposition occurs at the time of insertion, and secondary malposition (migration) can occur later after a period of correct positioning.

5.1. Incidence and scenarios

Malpositioning is common when ports are placed without real-time imaging. Early studies reported malposition rates of 5%–6% when postprocedure radiography was the first check.[1] Common sites for an incorrectly placed catheter include the ipsilateral internal jugular vein, contralateral brachiocephalic vein, and smaller veins.[41] With routine use of fluoroscopy during insertion, the incidence of unrecognized malposition has dropped, with current rates typically <1%–2% in experienced centers using imaging.[1] Although secondary migration of the catheter after correct placement is less common, it does occur. According to Skelton et al.,[5] 11 patients (2.0%) experienced catheter migration identified later during follow-up.

Malpositioning can lead to suboptimal port function and potentially dangerous complications. A catheter tip not in the central circulation may cause infusion of chemotherapy into a small vein or tissue, risking extravasation. There is also a risk of thrombosis in the vein where the malpositioned tip lies, owing to improper flow dynamics.

5.2. Risk factors

Several factors predispose patients to malpositioning during insertion or follow-up. Anatomical challenges, such as left-sided placement, requiring navigation of the acute angle between the left brachiocephalic vein and superior vena cava, predispose the internal mammary, azygos, or intercostal veins.[1] The absence of real-time imaging and reliance on anatomical landmarks markedly increases the risk of malposition; ultrasound guidance reduces arterial puncture and misplacement rates.[1] Procedural factors include inadequate catheter length, failure to secure the port pocket and catheter, and extra-anatomical tunneling. Patient factors, such as severe coughing, vomiting, or straining, can generate negative intrathoracic pressure and cause delayed migration or tip retraction. In a 2024 cohort of 142 breast-cancer patients, median tip retraction of –12.1 mm was observed between supine fluoroscopy and erect chest radiography, with port reservoirs shifting caudally by +31.4 mm.[42] Migration occurred in both the right- and left-sided ports, although zone migration to a more proximal venous segment was significantly associated with complications in left-sided ports.[42]

5.3. Prevention

The primary prevention of malpositioning was confirmed by imaging at the time of placement. Verifying the catheter tip location either by fluoroscopy or by intraoperative chest radiography is the standard of care. Immediate adjustments can be made if malpositioning is observed. Secure anchoring of the port and catheter is important to prevent late migration. Confirmation by imaging during insertion is essential to prevent malpositioning. Real-time fluoroscopy or ultrasonography combined with intraprocedural radiography ensures that the catheter tip is placed at the cavoatrial junction and allows immediate correction if a misplacement is detected. Routine postoperative chest radiography remains advisable for detecting malpositions or malrotations that may have been missed intraoperatively.[1] Ultrasound-guided venipuncture not only reduces arterial puncture rates but also prevents guidewire.[1] Proper tunneling to avoid pinching-off between the clavicle and first rib, adequate catheter length, and secure anchoring of the port and catheter help prevent late migration. Patients should be counseled to avoid vigorous coughing or straining immediately after the insertion. In a study comparing the right- and left-sided ports, routine follow-up imaging in the upright position was recommended because the tip position can shift significantly between the supine and erect postures.[42]

5.4. Management

If malposition was identified during insertion, it was immediately corrected. For malpositions discovered after this, the port should not be used for infusion until corrected. The management options include the following:

1. Interventional radiology repositioning: An interventional radiologist can often reposition a malpositioned catheter without performing a full surgery.
2. Surgical adjustment: The simplest solution is to return the patient to the procedure suite, expose the port-catheter connection, and feed a new guidewire down the catheter.
3. Port removal and replacement: If repositioning attempts are not possible or fail.
4. Conservative approach: In rare instances, if malposition is minor, the port is functional.

5.5. Outcomes

Timely recognition and correction of malpositioning generally result in good outcomes. When a malposition is corrected at insertion or soon thereafter, the port typically functions normally, and the complication rates resemble those of correctly placed devices. However, undetected malposition can lead to serious complications: infusion into small veins causes extravasation injury, phlebitis, and potential tissue necrosis; malposition in the right side of the heart may trigger arrhythmias or valve injury[1]; arterial malposition can cause pseudoaneurysm, fistula, stroke, or life-threatening bleeding if not recognized and corrected.[1] Malposition-related complications included infections, venous thromboses, port rotation, and fibrin sheath formation, but the rates did not differ significantly between right- and left-sided ports. Most complications were managed successfully, with zone migration being the only factor significantly associated with complications in the left-sided ports. Overall, vigilant imaging surveillance and adherence to the recommended techniques ensure that malpositioning remains a manageable complication rather than a cause of major morbidity.

6. Management strategies and outcomes overview

The management of Port-A complications ranges from conservative (eg, anticoagulation for thrombosis and antibiotics for minor infections) to intervention (eg, port removal, surgical correction, and radiological retrieval of fragments). The outcomes are favorable in the vast majority of cases in which these complications are managed appropriately. Early detection is a recurring theme; complications such as infection, thrombosis, and malposition have much better outcomes when identified early and treated before progression. These findings highlight the importance of routine monitoring and patient education.

7. Global perspective and low-resource settings

Most port studies originated from high-income countries; however, low- and middle-income regions are rapidly adopting these ports. A 2022 Nigerian study of 100 patients reported 13% complication rate (0.478/1000 catheter-days), with no deaths, pneumothorax, or catheter-associated thrombosis.[43] The authors

concluded that totally implantable venous access ports could be used successfully in sub-Saharan Africa, and advocated wider adoption to improve patient experience and treatment delivery.[43] Similarly, an Indian series found that malposition was the most common intraoperative complication (9.2%), whereas postoperative infections occurred in 7.5% of patients.[16] These studies suggest that with trained staff and meticulous care, complication rates in low-resource settings can mirror those in developed regions.[43] Nevertheless, limited access to fluoroscopy and ultrasonography necessitates alternative confirmation methods (eg, electrocardiography-guided tip placement) and simplified training protocols to ensure safe and sustainable port implantation.

8. Ongoing controversies: prophylactic anticoagulation and timing of port use

Whether prophylactic anticoagulants should be routinely administered remains controversial. The recent literature review by Abdel-Razeq et al.[44] noted that multiple randomized trials, including AVERT and TRIM-Line, evaluated apixaban or rivaroxaban for primary thromboprophylaxis in cancer patients with central venous catheters. In the AVERT trial's central venous catheter subgroup, apixaban reduced VTE to 4.8% compared with 18.7% in placebo, without a significant increase in major bleeding.[44] However, the overall meta-analysis showed that prophylaxis reduces VTE but increases minor bleeding[44]; therefore, international guidelines recommend prophylaxis only for high-risk patients.[45] Another debate concerns whether ports should be used first. A Korean retrospective study reported that commencing chemotherapy within 2 days of port implantation was safe; no complications occurred within 7 days, suggesting that immediate use may be feasible.[46] Others advocate waiting 6 to 7 days to allow tissue healing. These conflicting findings highlight a gap in evidence. Prospective trials comparing immediate versus delayed use and stratified prophylaxis are needed.

9. Novel insights, clinical algorithms, and critical synthesis

Recent data on venous access ports for patients with cancer emphasize the need for risk-stratified management strategies. Large randomized trials and meta-analyses have shown that DOACs such as apixaban and rivaroxaban can reduce VTE without a significant increase in major bleeding.[44] Risk-assessment models such as the Khorana and COMPASS-CAT scores integrate patient characteristics (cancer type, body mass index, blood counts) and port presence to classify patients into low/intermediate or high-risk groups.[44] Based on these tools, a practical algorithm is used to calculate a risk-assessment model score before-insertion, consider prophylactic DOACs for high-risk patients, avoid routine prophylaxis in low-risk patients, monitor high-risk patients with ultrasound at set intervals, and educate them on early symptoms. A meta-analysis of prophylaxis trials found that VTE occurred in 7.6% of prophylaxis-treated patients versus 13% of controls (OR = 0.51), with no significant increase in major bleeding.[44] These insights support the integration of evidence-based algorithms into port care protocols rather than summarizing incidence alone, thereby enhancing this review's academic contribution.

10. Conclusion

Port-A catheters are vital in oncology and chronic illness care, providing reliable venous access despite the associated complications. Although infections and thrombosis remain the most common serious complications, they can be mitigated using sterile techniques, prophylactic measures, ultrasound-guided insertion, and proper catheter placement. When complications arise, prompt multidisciplinary management is crucial because most patients recover without long-term adverse effects. Several issues can be addressed without removing the port, although removal should not be delayed when necessary. Preventive strategies (careful insertion, appropriate site selection, delayed initial use, maintenance protocols, and patient education) and standardized response algorithms significantly reduce risks, while technological advances continue to improve outcomes, ensuring that the benefits of avoiding repeated peripheral IVs generally outweigh the risks, particularly when institutions implement proper complication prevention protocols.

Acknowledgments

We appreciate the knowledge consultation provided by the Genomic and Proteomic Core Laboratory of the Department of Medical Research, Kaohsiung Chang Gung Memorial Hospital.

Author contributions

C-HT: writing - original draft. H-TL: validation. C-HH: conceptualization and supervision. All authors have read and agreed to the final version of the manuscript.

Data availability statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Financial support and sponsorship

This study was supported by grants from Chang Gung Memorial Hospital (CMRPG8N0051 and CMRPG8P0751).

Conflicts of interest statement

C-HH., an editorial board member at *Formosan Journal of Surgery*, had no role in the peer review process of or decision to publish this article. All authors declared no conflicts of interest in writing this paper.

Declaration of generative AI in scientific writing

During the preparation of this work, the first author used ChatGPT 5.0 in order to check the spelling, grammar, and mismatch of the references. After using this tool/service, the corresponding author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

References

[1] Machat S, Eisenhuber E, Pfarl G, et al. Complications of central venous port systems: a pictorial review. *Insights Imaging*. 2019;10:86.
[2] Wu J-M, Chang K-H, Hsu FL-T. Immunonutrition of perioperative therapy for colorectal cancer. *Formos J Surg*. 2023;56:9–11.
[3] Lebeaux D, Fernández-Hidalgo N, Chauhan A, et al. Management of infections related to totally implantable venous-access ports: challenges and perspectives. *Lancet Infect Dis*. 2014;14:146–159.
[4] Kim DH, Ryu DY, Jung HJ, Lee SS. Evaluation of complications of totally implantable central venous port system insertion. *Exp Ther Med*. 2019;17:2013–2018.
[5] Skelton WP, Franke AJ, Welniak S, et al. Investigation of complications following port insertion in a cancer patient population: a retrospective analysis. *Clin Med Insights Oncol*. 2019;13:1179554919844770.

[6] Kakkos A, Bresson L, Hudry D, et al. Complication-related removal of totally implantable venous access port systems: does the interval between placement and first use and the neutropenia-inducing potential of chemotherapy regimens influence their incidence? A four-year prospective study of 4045 patients. *Eur J Surg Oncol*. 2017;43:689–695.
[7] Shim J, Seo TS, Song MG, et al. Incidence and risk factors of infectious complications related to implantable venous-access ports. *Korean J Radiol*. 2014;15:494–500.
[8] Mariam A, Hegde N, Srinivasan A, Thangadorai R. Clinical profile of febrile neutropenia in children with malignancies in a tertiary care hospital: a prospective observational study. *Ind J Med Paediatr Oncol*. 2025;46:77–86.
[9] Pinelli F, Cecero E, Degl'Innocenti D, et al. Infection of totally implantable venous access devices: a review of the literature. *J Vasc Access*. 2018;19:230–242.
[10] Zawacki W, Walker T, DeVasher E, et al. Wound dehiscence or failure to heal following venous access port placement in patients receiving bevacizumab therapy. *J Vasc Interv Radiol*. 2009;20:624–627.
[11] Ladha H, Pawar T, Gilbert M, et al. Wound healing complications in brain tumor patients on Bevacizumab. *J Neurooncol*. 2015;124:501–506.
[12] Yun J, Baek G, Indorf A, Duong A. Incidence of port site complications in relation to timing of bevacizumab infusion. *J Oncol Pharm Pract*. 2024;31:528–533.
[13] Koehler D, Haus J-M, Shenas F, et al. Infectious complications of radiologically placed upper arm ports: a single center analysis. *PLoS One*. 2023;18:e0284475.
[14] Kurtipek FB, Yozgat AK, Kanık-Yüksek S, et al. Antibiotic lock therapy for port catheter-related infections of children with acute leukemia. *Mediterr J Hematol Infect Dis*. 2024;16:e2024072.
[15] Horino T, Hori S. Metastatic infection during Staphylococcus aureus bacteremia. *J Infect Chemother*. 2020;26:162–169.
[16] Sharma V, Pandey A. A spectrum of chemoport-associated complications and their management in cancer patients. *Cureus*. 2024;16:e58052.
[17] Yukisawa S, Fujiwara Y, Yamamoto Y, et al. Upper-extremity deep vein thrombosis related to central venous port systems implanted in cancer patients. *Br J Radiol*. 2010;83:850–853.
[18] Marin A, Bull L, Kinzie M, Andresen M. Central catheter-associated deep vein thrombosis in cancer: clinical course, prophylaxis, treatment. *BMJ Support Palliat Care*. 2021;11:371–380.
[19] Cominacini M, De Marchi S, Tosi F, et al. Incidence and clinical progression of asymptomatic peripherally inserted central catheter-related thrombosis in solid neoplasm patients: ultrasound insights from a prospective cohort study. *Res Pract Thromb Haemost*. 2024;8:102391.
[20] Lianos G, Hasemaki N, Tzima E, et al. Superior vena cava syndrome due to central port catheter thrombosis: a real life-threatening condition. *G Chir*. 2018;39:101–106.
[21] Kuter D. Thrombotic complications of central venous catheters in cancer patients. *Oncologist*. 2004;9:207–216.
[22] Puiggròs C, Cuerda C, Virgili N, et al; Grupo NADYA-SENPE. Catheter occlusion and venous thrombosis prevention and incidence in adult home parenteral nutrition (HPN) programme patients. *Nutr Hosp*. 2012;27:256–261.
[23] Saber W, Moua T, Williams EC, et al. Risk factors for catheter-related thrombosis (CRT) in cancer patients: a patient-level data (IPD) meta-analysis of clinical trials and prospective studies. *J Thromb Haemost*. 2011;9:312–319.
[24] Saber W, Moua T, Williams E, et al. Independent risk factors of catheter-related thrombosis (CRT) in adult cancer patients: an individual patient-level data (IPD) meta-analysis of randomized clinical trials and prospective cohort studies. *Blood*. 2008;112:3814–3814.
[25] Song MG, Seo T, Kang E, Yong H, Seo J, Choi YY. Innominate vein stenosis in breast cancer patients after totally implantable venous access port placement. *J Vasc Access*. 2015;16:315–320.
[26] Sone M, Arai Y, Sugawara S, Tomita K. Right-versus left-subclavian central venous port for patients with malignant tumor: a retrospective comparison of adverse events and imaging findings. *Interv Radiol*. 2018;3:121–125.
[27] Dridi M, Mejri N, Labidi S, et al. Implantable port thrombosis in cancer patients: a monocentric experience. *Cancer Biol Med*. 2016;13:384–388.
[28] Nobili E, Cicilia R D, Battista M D, et al. Venous thromboembolism and port-related thrombosis in metastatic colorectal cancer patients: a monocenter experience. *Pathophysiol Haemost Thromb*. 2010;37:30–34.
[29] Clatot F, Fontanilles M, Lefebvre L, et al. Randomised phase II trial evaluating the safety of peripherally inserted catheters versus implanted port catheters during adjuvant chemotherapy in patients with early breast cancer. *Eur J Cancer*. 2020;126:116–124.
[30] Granic M, Zdravkovic D, Krstajic S, et al. Totally implantable central venous catheters of the port-a-cath type: complications due to its use in the treatment of cancer patients. *J BUON*. 2014;19:842–846.
[31] Key NS, Khorana AA, Kuderer NM, et al. Venous thromboembolism prophylaxis and treatment in patients with cancer: ASCO clinical practice guideline update. *J Clin Oncol*. 2020;38:496–520.
[32] Lyman GH, Bohlke K, Khorana AA, et al; American Society of Clinical Oncology. Venous thromboembolism prophylaxis and treatment in patients with cancer: American Society of Clinical Oncology clinical practice guideline update 2014. *J Clin Oncol*. 2015;33:654–656.
[33] Jung PY, Ryu H, Jung JH, et al. Complications of central venous totally implantable access port: internal jugular versus subclavian access. *Korean J Crit Care Med*. 2015;30:13–17.
[34] Golamari R, Sedhai Y, Ramireddy K, Bhattacharya P. Atrial fibrillation induced by peripherally inserted central catheters. *Proc (Bayl Univ Med Cent)*. 2019;33:83–84.
[35] Bassareo P, Marras A, Marras M, Marras S, Mercuro G. Atrial fibrillation in a preterm newborn with structurally normal heart. *Oxf Med Case Rep*. 2017;2017:omx010.
[36] McGee W. Central venous catheterization: better and worse. *J Intensive Care Med*. 2006;21:51–53.
[37] Lalwani KA. Migrating central venous catheter. *Anaesthesia*. 1994;49:1105.
[38] Cova V. Training and protocolization in the use of port cath: improving patient safety and quality of care. *Health Lead Qual Life*. 2024;3:281.
[39] Diaz J, Rai S, Wu X-T, Chao J, Dias A, Kloecker G. Phase II trial on extending the maintenance flushing interval of implanted ports. *J Oncol Pract*. 2017;13:e22–e28.
[40] Wu X, Zhang T, Chen L, Chen X. Prolonging the flush-lock interval of totally implantable venous access ports in patients with cancer: a systematic review and meta-analysis. *J Vasc Access*. 2020;22:814–821.
[41] Liu W, Han Q, Li L, Chi J, Liu X, Gu Y. Catheter malposition analysis of totally implantable venous access port in breast cancer patients. *Front Surg*. 2023;9:1061826.
[42] O'Mahony AT, Coffey A, O'Regan PW, et al. Catheter tip migration in female patients with breast cancer: a retrospective comparative study of right- and left-sided chest ports. *Breast J*. 2024;2024:7358397.
[43] Salawu K, Arowojolu O, Afolaranmi O, Jimoh M, Nworgu C, Falase B. Totally implantable venous access ports and associated complications in sub-Saharan Africa: a single-centre retrospective analysis. *Ecancermedicalscience*. 2022;16:1389.
[44] Abdel-Razeq H, Al-Jaghbeer MJ. Primary thromboprophylaxis for the prevention of venous thromboembolism in cancer patients with central venous catheters: a literature review. *J Clin Med*. 2024;13:1660.
[45] Farge D, Frere C, Connors JM, et al; International Initiative on Thrombosis and Cancer (ITAC) Advisory Panel. 2022 International clinical practice guidelines for the treatment and prophylaxis of venous thromboembolism in patients with cancer, including patients with COVID-19. *Lancet Oncol*. 2022;23:e334–e347.
[46] Lee J, Hur SM, Kim Z, Lim CW. Safety of immediate use of totally implantable venous access ports in adult patients with cancer: a retrospective single-center study. *Korean J Clin Oncol*. 2021;17:104–110.
[47] Mohammad NM, Naing NN, Siti-Azrin AH, Wnawa SY. Factors associated with unscheduled venous access port removal due to complications. *Gülhane Med J*. 2024;66:94–99.
[48] Li Y, Guo J, Zhang Y, Kong J. Complications from port-a-cath system implantation in adults with malignant tumors: a 10-year ssingle-center retrospective study. *J Interv Med*. 2022;5:15–22.
[49] Wu CY, Fu JY, Feng PH, et al. Risk factors and possible mechanisms of intravenous port catheter migration. *Eur J Vasc Endovasc Surg*. 2012;44:82–87.
[50] Marcy P, Figl A, Amoretti N, Ianessi A. Arm port implantation in cancer patients. *Int J Clin Oncol*. 2010;15:328–330.

[51] Rebahi H, Eladib A, Boudari S, McCaughey C, Younous S. An early migration of an implantable port catheter: where and how should we place the catheter tip? *J Clin Case Rep*. 2013;3:315.
[52] Goltz J, Kickuth R. Reply to letter: further data about upper extremity ports. *Cardiovasc Intervent Radiol*. 2011;34:659–660.
[53] Wu C-Y, Hu H-C, Ko P, et al. Risk factors and possible mechanisms of superior vena cava intravenous port malfunction. *Ann Surg*. 2012;255:971–975.
[54] Marcy P, Italiano A. The percutaneous radiological correction rate is 0.5% in upper extremity port device cancer patients. *Cardiovasc Intervent Radiol*. 2008;31:675.
[55] House L, Yen A, Bokoch M. Central venous catheter in the internal mammary vein. *Anesthesiology*. 2019;131:397.
[56] Osman O, El-Magzoub A-R, Elamin S. Prevalence and risk factors of central venous stenosis among prevalent hemodialysis patients, a single center experience. *Arab J Nephrol Transplant*. 2014;7:45–47.
[57] Zhang L, Wu J. The utilization of guidewires for adjusting the intraoperative catheter malposition during the venous access port implantation: a retrospective study. *Medicine (Baltimore)*. 2024;103:e40461.
[58] Sekiguchi K, Takano H. Knot formation of a guidewire during subclavian venous catheterization: a case report. *Radiol Case Rep*. 2022;17:3923–3926.
[59] Wallace J, Afonso E, Yu H, Birchard K, Isaacson A. Factors that predict increased catheter tip movement in left internal jugular vein implantable venous access ports upon standing. *J Vasc Access*. 2015;16:223–226.
[60] Benvenuti S, Pintossi C, Porteri E, et al. Pseudo-tunneling procedure for PICC-ports catheters insertion in patients with small veins at the middle third of the arm. *Minerva Surg*. 2024;79:594–599.
[61] Marcy P, Lacout A, Amoretti N, Figl A, Thariat J, Simon JJ. Criteria to choose between distal or proximal venous port device insertion in HNC patients. *Cardiovasc Intervent Radiol*. 2013;36:874–875.