Expert Review of Medical Devices

ISSN: 1743-4440 (Print) 1745-2422 (Online) Journal homepage: www.tandfonline.com/journals/ierd20

Totally implanted ports and peripherally inserted central catheters for chemotherapy: a systematic review and meta-analysis of clinical outcomes and economic evaluations

Carla Rognoni, Baudolino Mussa & Rosanna Tarricone

To cite this article: Carla Rognoni, Baudolino Mussa & Rosanna Tarricone (10 Feb 2026): Totally implanted ports and peripherally inserted central catheters for chemotherapy: a systematic review and meta-analysis of clinical outcomes and economic evaluations, Expert Review of Medical Devices, DOI: 10.1080/17434440.2026.2625370

To link to this article: https://doi.org/10.1080/17434440.2026.2625370

Published online: 10 Feb 2026.

EXPERT REVIEW OF MEDICAL DEVICES
https://doi.org/10.1080/17434440.2026.2625370

Taylor & Francis
Taylor & Francis Group

META-ANALYSIS

OPEN ACCESS   Check for updates

Totally implanted ports and peripherally inserted central catheters for chemotherapy: a systematic review and meta-analysis of clinical outcomes and economic evaluations

Carla Rognoni [a], Baudolino Mussa [b] and Rosanna Tarricone [a,c]

[a]Centre for Research on Health and Social Care Management (CERGAS), SDA Bocconi School of Management, Bocconi University, Milan, Italy; [b]Surgical Science Department, University of Turin, Turin, Italy; [c]Department of Social and Political Sciences, Bocconi University, Milan, Italy

ABSTRACT

Objectives: Chemotherapy, while effective, can damage blood vessels due to repeated punctures and drug irritants, leading to complications like tissue damage from infiltration, clots, and phlebitis. To reduce these risks and improve patient comfort, venous catheters such as centrally inserted access ports (PORTs) and peripherally inserted central catheters (PICCs) are commonly used.
Methods: This study systematically reviewed and analyzed clinical and economic data comparing PORTs and PICCs in adult chemotherapy patients, considering randomized trials, observational studies, and cost-effectiveness analyses. Data on complications and costs were extracted, and meta-analyses were conducted. Risk of bias was also assessed.
Results: Sixty-three studies were included. PORTs showed significantly lower rates (per 1000 catheter-days) of thrombosis, local infections, and catheter malposition compared to PICCs. Similar trends were seen for wound complications and mechanical issues. Economic analyses favored PORTs for cost-effectiveness. Study limitations included heterogeneity and potential bias, though overall quality was moderate to good.
Conclusion: Findings support the clinical and economic value of PORTs for long-term chemotherapy, difficult venous access, and low-maintenance needs, whereas PICCs suit shorter treatment durations, patients unsuitable for minor surgery, or settings favoring bedside insertion. Decisions should align with the goals of the European Health Technology Assessment Regulation to harmonize medical device evaluation across Europe.

ARTICLE HISTORY
Received 13 June 2025
Accepted 13 January 2026

KEYWORDS
Chemotherapy; PICC; PORT; venous access; meta-analyses; complications; costs

1. Introduction

Chemotherapy remains one of the most effective treatments for cancer. However, the repeated venous punctures required for chemotherapy can cause vascular damage, and many chemotherapy drugs have strong irritant and corrosive effects if they extravasate, leading to side effects like phlebitis [1,2]. To protect patients' blood vessels from these corrosive drugs and minimize pain, central venous catheters are commonly used in clinical practice [3]. Besides administering chemotherapeutic agents, central or peripheral catheters can also be utilized for delivering bolus or maintenance nutrient solutions, medications, or blood products [4].

Two of the most widely used medium- and long-term intravenous infusion devices are: centrally inserted totally implanted access ports (PORTs), and peripherally inserted central catheters (PICCs) [5].

PICC and PORT placement differ in technique, site, and upkeep. PICC lines are inserted at the bedside via a peripheral arm vein under ultrasound and advanced to the superior vena cava, making them easy to place/remove but requiring frequent maintenance (flushing, dressing changes) and carrying higher risks of infection or displacement [6]. PORTs are implanted subcutaneously in the chest via a minor surgical procedure, with a tunneled catheter to a central vein; they are more invasive to place/remove but offer better long-term durability and convenience for prolonged chemotherapy, with no external components or routine dressing changes [6].

Recently, there has been growing concern over whether PICC or PORT is the superior vascular access strategy for cancer patients. PICCs are easily implanted and removed but require weekly maintenance, whereas PORTs necessitate monthly maintenance, typically performed at the end of chemotherapy sessions. Oncologists may favor PICCs over PORTs due to their ease of implantation by nursing teams without the need for surgery and their lower associated costs [7]. Additionally, PICCs can be quickly removed in cases of infection or thrombosis for source control. However, previous studies have reported a higher complication rate in oncology patients with PICCs compared to those with PORTs [8,9].

Several meta-analyses have been conducted to compare the safety and efficacy of PICCs versus PORTs. However, they have important limitations: they often (i) focus on a single clinical endpoint [10] (e.g. VTE or infection), (ii) restrict

CONTACT Carla Rognoni carla.rognoni@unibocconi.it Centre for Research on Health and Social Care Management (CERGAS), SDA Bocconi School of Management, Bocconi University, Via Sarfatti 10, Milan 20136, Italy

Supplemental data for this article can be accessed online at https://doi.org/10.1080/17434440.2026.2625370

inclusion to specific malignancies [11,12], or (iii) analyze only randomized trials [13]. Therefore, a comprehensive meta-analysis that synthesizes all available studies across malignancy types and evaluates multiple clinically relevant endpoints is warranted.

The aim of this study is to support the decision-making process regarding the management options for patients requiring a vascular access for chemotherapy. In particular, the scope is to systematically review and compare the clinical outcomes and economic evaluations of PORTs and PICCs used for chemotherapy administration in adult cancer patients.

Ultimately, the research project seeks to enhance awareness of the type, quantity, and quality of evidence required to inform healthcare decision-making, particularly in the medical device sector, where specific knowledge may be limited.

2. Material and methods

All available information on the two types of devices was systematically gathered through a systematic literature review conducted within the scope of the study. Parameters with adequate quantitative data for a reliable comparison were then examined using meta-analyses. Cost-effectiveness studies were collected and analyzed in a subsequent, separate phase.

2.1. Systematic literature review

A systematic literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [14]. The review framework was structured around four core elements – Population, Intervention, Comparator, and Outcomes (PICO). Table 1 shows the PICO components.

Clinical outcomes were categorized based on definitions most frequently used across the included studies.

Thrombosis was defined as the formation of a blood clot (thrombus) inside or around the catheter, which could partially or completely occlude the vein or the device lumen. Events included symptomatic and/or radiographically confirmed thromboses that interfered with catheter function or required medical intervention (e.g. anticoagulation, thrombolysis, or device removal).

Infections were classified as either (i) severe infections or catheter-related bloodstream infections (CRBSIs) -infections attributed to the catheter that required systemic therapy or device removal – or (ii) local/device infections, such as erythema, port-pocket or exit-site inflammation, or cellulitis without bloodstream involvement.

Catheter occlusion referred to the inability to infuse or aspirate through the catheter due to blockage from thrombotic or mechanical causes. Occlusions that required thrombolytic therapy, catheter replacement, or removal were included.

Wound problems encompassed wound dehiscence (partial or complete reopening of the surgical incision) and fibrin sheath formation around the catheter, both considered markers of inadequate healing or tissue response to the implanted device.

Hematoma/ecchymosis described localized bleeding or bruising at the insertion site or around the port pocket, generally due to vessel injury or poor hemostasis during or after insertion. In PICCs, it may occur at the insertion site due to vein trauma, while in PORTs, it can develop around the port pocket or catheter entry point. Immediate pressure application, cold compresses, and monitoring can help manage it, preventing complications like infection or catheter dysfunction.

Bleeding events referred to intra- or post-procedural bleeding at the catheter site, including minor oozing or more extensive hemorrhage around the port or access pocket, sometimes requiring hemostatic measures or prolonged compression.

Arterial puncture denoted inadvertent arterial cannulation during insertion (e.g. brachial, carotid, or subclavian artery), typically confirmed visually or by imaging and managed by immediate needle removal and pressure application.

Mechanical malfunction encompassed structural device failures (e.g. valve failure, kinking or damage) affecting infusion or blood withdrawal, leading to loss of catheter patency or replacement.

Catheter malposition or movement was defined as displacement, migration, or flipping of the catheter or port identified clinically or by imaging, which could result in impaired infusion or necessitate repositioning.

Catheter fracture or rupture referred to partial or complete breakage of the catheter wall, often due to mechanical stress, excessive flushing pressure, or pinch-off syndrome, potentially causing leakage or embolization.

Drug extravasation or leakage described the escape of infusate into surrounding tissues or outside the vascular system, either due to catheter rupture, septum damage, or dislodgement, leading to potential local tissue injury or infusion failure.

Inclusion criteria were the following:

- Timeframe: studies from 2015 onward; catheter/device use from ≥2015
- Designs: randomized controlled trials, prospective/retrospective observational studies, and cost-effectiveness analyses

Table 1. PICO elements.

PICO element	Description
Population	Adults undergoing chemotherapy for any types of tumors
Intervention	Centrally inserted totally implanted access ports (PORTs)
Comparator	Peripherally inserted central catheters (PICCs)
Outcomes	Outcomes encompassed relevant clinical and economic data. Selected clinical outcomes were: thrombosis episodes, infections (local infection or severe/bloodstream infections), device occlusions, wound problems, hematoma/ecchymosis, bleeding events, cases of arterial puncture, mechanical malfunction, rates of catheter malposition/movement, catheter fracture/rupture, episodes of drug extravasation/leakage.

- Language: English
- Intervention focus: devices used primarily for chemotherapy
- Population: within the scope of this review (i.e. non-pediatric, non-COVID cohorts)
- Sample size: ≥5 participants

Exclusion criteria:

- Timeframe:studies before 2015 or studies using catheters/devices before 2015.
- Designs:case reports/series with < 5 participants
- Language:publications not in English
- Population:pediatric studies; COVID-related cohorts (to avoid bias toward unfavorable outcomes); other populations outside scope
- Intervention focus:studies where devices were not mainly for chemotherapy (e.g. mixed uses such as nutrition support).

A detailed research protocol was formulated for the study and registered in PROSPERO, the international prospective register of systematic reviews (ID CRD42025643151).

This review was designed as a targeted evidence synthesis. To maintain a focused, manageable search while ensuring coverage relevant to our topic, we searched PubMed/MEDLINE and Web of Science (Core Collection) using the same search string, executed in November 2024. These databases were chosen for their broad biomedical/multidisciplinary reach and substantial overlap with other major databases [15].

The search strategy is reported in the Appendix. Duplicates across the two databases were removed using RefWorks, followed by a manual verification to ensure accuracy, as slight formatting differences can occasionally prevent duplicates from being identified. Two reviewers (CR, BM) independently screened all retrieved titles and abstracts, and subsequently assessed the full texts of potentially eligible studies. Discrepancies between reviewers were resolved through discussion and by involving a third reviewer (RT).

This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

2.2. Data extraction

The data were extracted into an Excel file, including study type (RCT, observational, or other), country, number of patients or devices studied, type of cancer and period of catheters use. When the data was available, the frequency of complications was estimated according to the number on 1000-catheter days.

For the economic analysis, studies presenting cost-effectiveness or cost-utility assessment of the different devices across various settings were evaluated. Non-monetary outcomes, such as patients' quality-of life, were also considered for comparison.

2.3. Statistical analyses

Meta-analyses were conducted on numeric outcomes that allowed to compare the two types of devices. Studies involving PORTs or PICCs were analyzed separately to consider all available evidence, including both single-arm and comparative studies. The analysis followed the Cochrane Guidelines for Systematic Reviews [16]. The software STATA was used to perform the meta-analyses using a random effects maximum likelihood model for all parameters to take into account heterogeneity across the studies. The results are presented graphically using forest plots, which show the effect size (ES) of each study with the corresponding 95% confidence interval (95%CI), the overall ES of all selected studies and the degree of heterogeneity across them (quantified using the I^2 metric: the higher the value, from 0% to 100%, the larger the heterogeneity). In the forest plots, studies are presented in chronological order followed by alphabetical order. Outcome values for the two devices were compared by evaluating the confidence intervals for each group. A conservative approach was adopted: overlapping confidence intervals were interpreted as indicating no statistically significant difference between groups. Conversely, the absence of overlap was considered evidence of a statistically significant difference between the population means [17].

Cost data were synthesized descriptively because of variations in study design, reporting formats, currencies, and time horizons, which precluded quantitative pooling. To facilitate comparisons, all costs were standardized and reported in 2025 Euros (EUR 2025).

2.4. Risk of bias assessment

The studies included in the meta-analyses were appraised to evaluate their methodological quality and identify potential biases in design, conduct, and analysis. The selected papers were assessed using the modified Downs and Black checklist, a validated tool for evaluating the quality of both RCTs and observational studies [18,19]. This checklist assigns a maximum score of 28 points for randomized studies and 25 points for non-randomized studies. Based on the total score, studies are categorized as excellent (26–28 points), good (20–25 points), moderate (15–19 points), or poor (≤14 points) in methodological quality [19].

To provide a comprehensive evaluation of the risk of bias, we incorporated both the Risk of Bias 2 (ROB 2) tool [20] and the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool [21] in a supplementary analysis to confirm our quality assessment findings. The ROB 2 tool, developed by the Cochrane Collaboration, is designed to assess bias in randomized controlled trials across five domains: the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. The ROBINS-I tool, also from Cochrane, evaluates bias in non-randomized studies by considering seven domains that account for confounding, participant selection, intervention classification, deviations from intended interventions, missing data, outcome measurement, and selective reporting. Together, these tools allow for a structured and transparent appraisal of internal validity across both experimental and observational study designs.

3. Results

The screening process is outlined in Figure 1. A total of 3283 studies were retrieved from Pubmed and Web of Science databases. After removing 1068 duplicates, the remaining 2215 articles were screened by title and abstract to determine their relevance to the study's scope. Of these, 254 papers were deemed relevant and subjected to a full read. Ultimately, 63 papers were included in the final analysis [22–83]. A summary of study and patients characteristics is reported in Supplementary Table S1.

An analysis of the geographical distribution of the papers included in this study reveals a notable trend: the majority of studies on this topic have been authored by researchers from China, Italy, and India. Moreover, Figure 2 highlights a minor presence of contributions from developing countries among the selected papers.

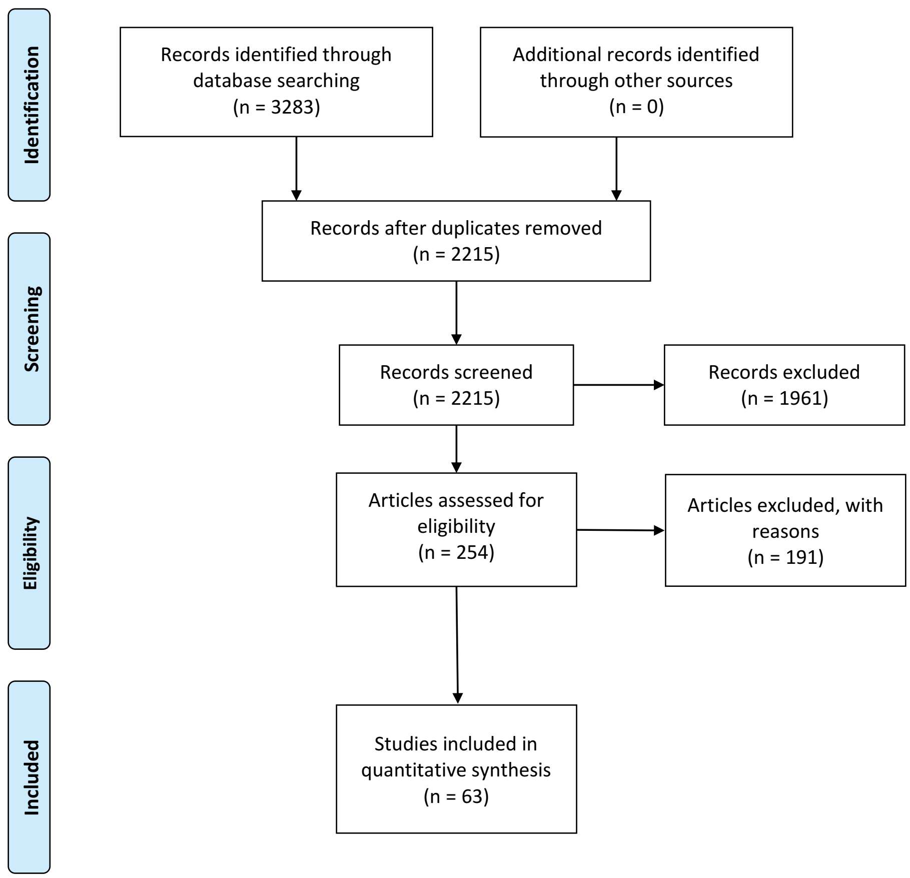

Figure 1. PRISMA diagram.

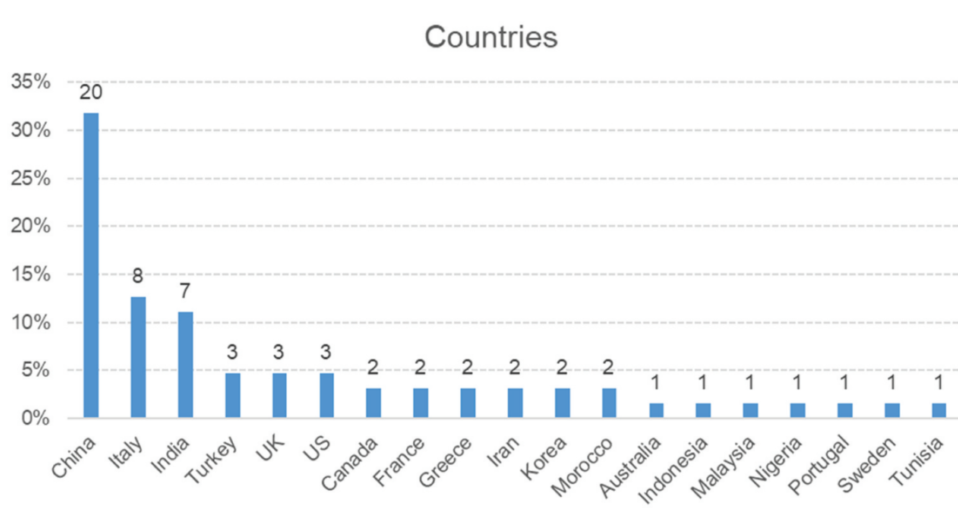

Figure 2. Distribution of studies by country.

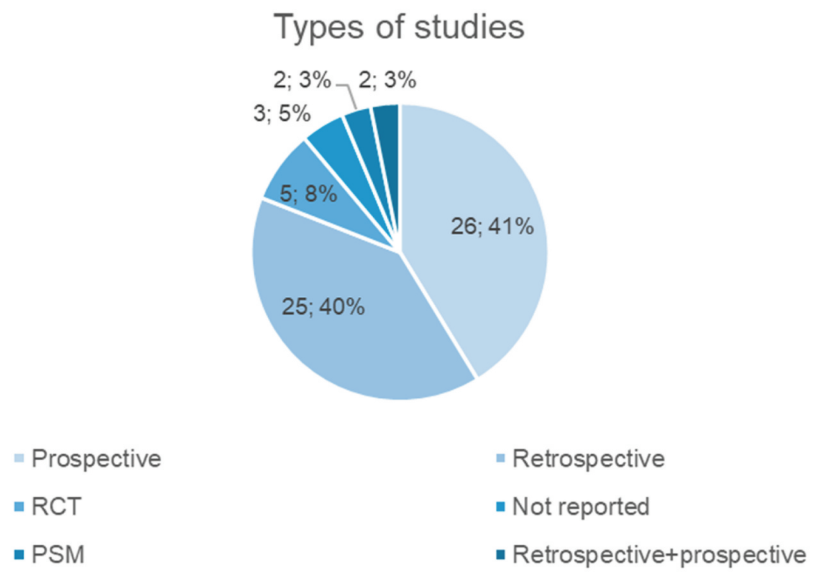

Figure 3. Study types.

Regarding the type of studies (Figure 3), a significant majority were either prospective (41%) or retrospective (40%). Only a small proportion (8%) focused on RCTs, and just two studies employed propensity-score matching (PSM) methodology to pair the two groups. The limited number of RCTs may be attributed to the challenges associated with their execution, particularly given the typically short-term use of PICCs compared to the long-term use of PORTs.

An analysis of the devices assessed revealed a predominant number of studies involving PORTs only ($N = 30$, 48%) compared to a smaller proportion of studies involving PICCs only ($N = 14$, 22%). Comparative studies were 18 (29%). One study that presented a cost-consequence analysis was model-based and used data from the literature to populate a model.

The following paragraph shows the results of the meta-analyses according to the clinical parameters.

3.1. Thrombosis episodes

PICC presents a significantly higher percentage of patients with thrombosis (7.3%, 95%CI 4.2–11.2%) compared to PORT (1.7%, 95%CI 1.1–2.5%) (Supplementary Figure S1). Heterogeneity across studies was high for both devices. The same conclusion arises from the analysis of events per 1000 catheter days, where PICCs showed a rate of 0.0156 (95%CI 0.0035–0.0361) compared to 0.0002 for PORTs (95%CI 0.0001–0.0004). The thrombosis episodes comparison between PICC and PORT is statistically significant.

3.2. Infections

Severe infections, defined as catheter-related bloodstream infections (CRBSI) or infections that required device removal, reported a lower frequency in PORTs (1.9%, 95%CI 1.0–3.1%) compared to PICCs (3.5%, 95%CI 1.6–5.8%). A similar conclusion emerges from the analysis of events per 1000 catheter-days, with PICCs exhibiting a rate of 0.0236 (95%CI 0.0000–0.0919) compared to 0.0009 for PORTs (95%CI 0.0002–0.0020). Heterogeneity was high in all the analyses. Although in both cases PORTs performed better compared to PICCs, the differences are not statistically significant due to the overlapping of the confidence intervals (Supplementary Figure S2).

Patients with PICC showed a higher rate of local/device infections (2.4%, 95%CI 0.9–4.5%) compared to PORT (1.1%, 95%CI 0.6–1.7%) (Supplementary Figure S3). Considering the rate of events on 1000 device-days, the conclusion was confirmed, with a value of 0.0006 (95%CI 0.0001–0.0017) for PORTs compared to a value of 0.0021 (95%CI 0.0018–0.0025) for PICCs. Heterogeneity across studies was low only for the assessment of the rate of events on 1000 device-days for PICCs, but this could be explained by the low number of studies considered (only two). In this case, also the difference between the two devices is statistically significant.

3.3. Catheter occlusion

Catheter occlusion involved 11.8% (95%CI 6.8–17.9%) of patients with PICC and 0.9% (95%CI 0.3–1.9%) of patients with PORT. The rates referred to 1000 catheter-days are respectively 0.0356 (95%CI 0.0000–0.1522) and 0.0001 (95%CI 0.000–0.0005) (Supplementary Figure S4). Heterogeneity among studies was high for all analyses. While the former analysis showed statistical significance, it was not confirmed in the latter.

3.4. Wound problems

Wound problems were more likely to happen for PICCs (7.7%, 95%CI 2.3–15.7%) than PORTs (0.9%, 95%CI 0.2–1.9%)

(Supplementary Figure 5), with statistically significant differences. There was a high degree of heterogeneity among studies for both catheter types.

3.5. Hematoma

PICCs and PORTs showed similar hematoma rates: 0.9% (95%CI 0.0–4.7%) for PICCs and 1.5% (95%CI 0.5–2.7%) for PORTs (Supplementary Figure 6). The level of heterogeneity among studies was high for both catheter types.

3.6. Bleeding

Similar bleeding rates were observed for PICCs and PORTs: 1.4% (95%CI 0.0–4.3%) for PICCs and 1.2% (95%CI 0.2–2.9%) for PORTs (Supplementary Figure 7). Heterogeneity was higher for PICCs compared to PORTs.

3.7. Arterial puncture

PICCs reported a higher rate of arterial puncture (3.5%, 95%CI 0.8–7.6%) compared to PORTs (1.3%, 95%CI 0.5–2.6%), but without statistical significance (Supplementary Figure 8). Heterogeneity was not present for studies on PICCs but this is likely due to the low number of studies (only two).

3.8. Mechanical malfunction

The analysis was limited to percentages of patients reporting the issue due to lack of specific rates on 1000 catheter-days. PICCs showed a statistically significant higher percent of patients with mechanical malfunction (25.5%, 95%CI 20.4–30.9%) compared to PORTs (3.8%, 95%CI 1.3–7.4%) (Supplementary Figure 9). Heterogeneity was not observed in studies on PICCs, but this is likely due to the limited number of studies (only two).

3.9. Malposition/Movement

PICCs showed a statistically significant higher rate of this issue, with 5.3% (95%CI 3.1–8.1%) of patients compared to PORTs that affected 1.1% (95%CI 0.5–1.1%) of patients. Similarly, PICCs reported a rate per 1000 catheter-days of 0.0047 (95% CI 0.0042–0.0053) compared to 0.0006 (95%CI 0.0000–0.0018) for PORTs (Supplementary Figure 10). Both study groups reported high heterogeneity.

3.10. Rupture

The analysis was limited to patients reporting the event due to lack of specific rates on 1000 catheter-days. PICCs showed a higher percent of patients with catheter rupture (1.3%, 95%CI 0.1–3.4%) compared to PORTs (0.1%, 95%CI 0.0–0.3%) (Supplementary Figure 11). Heterogeneity was high for both study groups.

3.11. Leakage

PICCs and PORTs showed overlapping leakage rates: 0.8% (95%CI 0.0–3.2%) for PICCs and 0.8% (95%CI 0.01–1.7%) for PORTs (Supplementary Figure S12).

3.12. Cost-effectiveness data

Cost-effectiveness analysis has become increasingly important in healthcare, assessing the balance between costs and health benefits of interventions [84]. Economic evidence for PORTs vs PICCs is limited to five studies: three provide formal cost-effectiveness (cost-utility) analyses, while two report cost-only comparisons.

Shao et al. [61] conducted a prospective observational study in 404 cancer patients in China, comparing costs (CNY Chinese Yuan) and complications between PICCs and PORTs. Health utility was measured with the EQ-5D-5 L questionnaire, and a cost-utility analysis was performed from the healthcare system perspective. Average total costs in 2012 were 4092 CNY (€590, 2025) for PICCs and 4,567 CNY (€659, 2025) for PORTs, corresponding to 0.46 and 0.475 QALYs, respectively, over six months. The incremental cost-utility ratio (ICUR) was 31,671 CNY (€4,565, 2025) per QALY. Sensitivity analyses confirmed result robustness, showing that at a willingness-to-pay threshold of 80,976 CNY (€11,670, 2025) per QALY (China's 2021 GDP per capita), PORTs had a 96% probability of being cost-effective. PORTs were more cost-effective than PICCs for dwell times of 6–12 months, leading the authors to recommend PORTs for medium- to long-term chemotherapy.

A second Chinese study [64] used propensity score matching to compare three catheter types – central venous catheters, PICCs, and PORTs – for long-term breast cancer chemotherapy. Health utilities were 0.88 for PICC and 0.94 for PORT, with median survival times of 0.41 vs. 2.85 years. Total costs were $828 (€850, 2025) for PICC and $1,122–$2,043 (€1,150–€2,096, 2025) for PORTs, depending on dwell time. ICURs showed PORTs were more cost-effective than both central catheters and PICCs, ranging from $2,878 (€2,953, 2025) for 6 months to $522 (€536, 2025) for > 12 months.

Wang et al. [62] performed another Chinese cost-effectiveness study (2019) from the hospital perspective using propensity matching. Instead of QALYs, outcomes were based on complication rates. Costs for 3–6, 6–9, and 9–12 months were $604 vs. $1,270 (€635 vs. €1,330, 2025), $731 vs. $1,414 (€770 vs. €1,484, 2025), and $967 vs. $1,588 (€1,016 vs. €1,670, 2025), respectively, favoring PICCs ($p < 0.001$). Complication rates were also lower for PICCs (e.g. 0.65 vs. 0.91 for 3–6 months). The authors concluded that PICCs were more cost-effective up to 9 months (ICER PORT vs. PICC $2564.08 [2,693€ 2025], 3–6 months, $1751.49 [1,839€ 2025] 6–9 months), whereas PORTs became more favorable beyond 9–12 months (ICER PORT vs. PICC $1,411.20 [1,481€ 2025]).

In Sweden, Taxbro et al. [38] conducted a randomized controlled trial with 399 cancer patients, including a health economic evaluation. Using 2020 data, total costs were €824.58 (€981, 2025) for PICCs and €662.34 (€775, 2025) for PORTs. Adjusted per day, costs were €6.58 (€7.70, 2025) for

PICCs and €3.01 (€3.52, 2025) for PORTs, confirming the lower per-day cost of PORTs.

Lastly, a Turkish study [67] compared costs (TRY Turkish lira) and quality of life (EORTC QLQ-C30) in patients receiving chemotherapy through PORTs or PICCs. Although quality of life was slightly higher for PORTs (77.1 ± 17.9 vs. 73.3 ± 24.3), the difference was not significant ($p = 0.377$). Similarly, total non-chemotherapy costs did not differ significantly (PORT: 435.46 TRY, about €66 [2025]; PICC: 389.85 TRY, about €59 [2025]; $p = 0.217$).

Overall, across studies, PORTs tend to be more cost-effective for long-term use, particularly beyond six months, whereas PICCs remain less costly and advantageous for shorter durations of therapy.

3.13. Risk of bias assessment

The assessment of studies quality (risk of bias) according to the modified Downs and Black checklist is reported in Supplementary Table 2. About half of the studies ($N = 32$, 51%) reported good quality while the remaining were fair ($N = 31$, 49%). No studies showed excellent or poor quality.

Statistically significant differences favoring PORTs over PICCs were confirmed in the rates (per 1000 catheter-days) of thrombosis, local infections, and catheter malposition or movement for the subgroup of studies reporting good quality (Supplementary Figures 13, 14, 15). For the same group of studies, also the fraction of patients experiencing mechanical malfunction showed a statistically significant improvement with PORTs compared to PICCs (Supplementary Figure 16).

The assessment of the risk of bias according to ROB 2 and ROBINS-I is reported in Supplementary Tables 3 and 4, respectively. A total of five randomized controlled trials (RCTs) were assessed using the ROB 2 tool, and 58 observational studies were evaluated using ROBINS-I.

Across all RCTs, the overall risk of bias was judged as 'some concerns.' Risk was generally low for the randomization process and missing outcome data, but some concerns persisted for deviations from intended interventions, outcome measurement, and selective reporting, mainly due to limited blinding and incomplete analytic reporting.

Considering the observational studies, the results showed that 57 studies (98.3%) were rated as having a moderate overall risk of bias, while only one study (1.7%) was judged to be at low risk. None were classified as serious or critical risk. Most studies demonstrated moderate risk across domains such as confounding, participant selection, and intervention classification, reflecting the inherent limitations of non-randomized designs. Bias due to missing data and measurement of outcomes was generally low, suggesting adequate completeness of follow-up and reliable outcome assessment. Overall, these findings indicate that the included observational studies were of moderate methodological quality, providing useful evidence but with some residual concerns regarding confounding and participant comparability.

In summary, there was agreement between the evaluations obtained using the modified Downs and Black checklist and those derived from the ROB 2 and ROBINS-I tools. The Downs and Black assessment classified the studies as good (51%) or fair quality (49%), with no studies rated excellent or poor, indicating an overall moderate methodological standard. Consistently, the ROB 2 assessment for the five RCTs identified an overall 'some concerns' risk, while the ROBINS-I evaluation of 58 observational studies showed a predominantly moderate risk of bias (98.3%).

Together, these results confirm a convergent appraisal of methodological quality, highlighting that the included studies were generally of acceptable quality with moderate risk of bias, mainly due to issues related to blinding, intervention adherence, and confounding, but with no evidence of severe or critical bias.

4. Discussion

The present study presented a comprehensive literature search to compile existing evidence on the use of PICCs and PORTs for the management of vascular access in adult patients undergoing chemotherapy.

Considering the differing lifespans of the two devices – PORTs lasting longer than PICCs [85] - the most reliable comparison of complications relies on the rate per 1000 catheter-days, which standardizes evaluation across a common time horizon. Within this framework, and based on the available evidence, PORTs show statistically superior outcomes compared to PICCs in terms of thrombosis episodes, local infections, and catheter malposition or displacement (see Figure 4 for a summary of estimated complication rates per 1000 catheter-days). Moreover, since PICCs have a significantly higher incidence of other complications – such as wound issues and mechanical malfunctions – it is likely that this conclusion would hold even when adjusting for a standardized time frame.

In our meta-analysis, PICC-related thrombosis occurred significantly more frequently than PORT-related thrombosis (0.0156 vs. 0.0002 per 1000 catheter days). This finding aligns with the results of Lin et al. [13], who reported a substantially higher risk of venous thromboembolism (VTE) in patients with PICCs compared with PORTs in a meta-analysis including over 20 studies. Similarly, Wang et al. [10] and Taxbro et al. [8] demonstrated an increased risk of catheter-related thrombosis with PICCs relative to PORTs in cancer populations. Taken together, this body of evidence consistently supports the superior thrombotic safety profile of PORTs, particularly for patients undergoing medium- to long-term chemotherapy, where the risk of PICC-related VTE accumulates over time.

Our analysis showed that local or device-related infections were less frequent with PORTs (0.0006 per 1000 catheter days) compared with PICCs (0.0021 per 1000 catheter days), confirming previously published evidence. Liu et al. [11] similarly found a significantly lower infection risk for PORTs, and Rieger et al. [9] reported higher cumulative infection rates for PICCs (11.9%) than for PORTs (6.4%) in patients receiving systemic anticancer therapy. These findings indicate that PORTs offer a safer profile regarding local and exit-site infections, especially for patients undergoing long-term chemotherapy.

The present study found a significantly higher rate of catheter malposition or migration in PICCs (0.0047 per 1000 catheter-days)

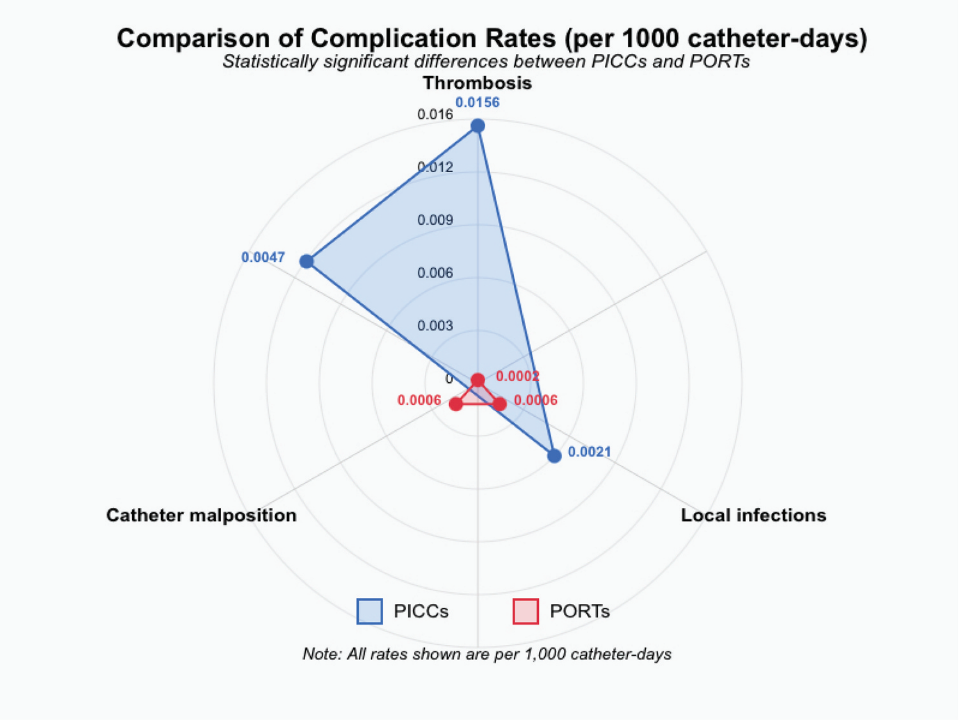

Figure 4. Summary of complication rates (per 1000 catheter-days) that showed statistically significant differences between PICCs and PORTs.

than in PORTs (0.0006 per 1000 catheter-days), consistent with previously reported evidence. Qiu et al. [86] conducted an RCT-based meta-analysis and reported a higher rate of catheter migration with PICCs (2.44%) compared to PORTs (0%), while a recent review [87] reported for PICCs a rate of catheter malposition and migration of 7.87%. The greater susceptibility of PICCs to movement likely arises from their longer external pathway and the influence of arm motion and venous anatomy, which can promote tip displacement or occlusion. In contrast, PORTs are tunneled and anchored subcutaneously, minimizing migration risk.

Complications not only raise costs associated with the management of the patients and for the healthcare personnel, but also amplify treatment complexity, potentially leading to interventional procedures [9]. An enhanced management of the patients with venous accesses for chemotherapy could lower costs for consumables and reduce the burden of managing potential complications.

Regarding costs, the collective findings from our analysis indicate that the cost-effectiveness of PICCs and PORTs can vary significantly based on the duration of use, the specific healthcare context, and regional practices. In oncology settings, for medium- to long-term intravenous delivery, PORTs tend to be more cost-effective than PICCs. This is largely due to lower overall costs and fewer complications associated with PORTs over longer dwelling times. However, the cost-effectiveness profile of these devices is not absolute. For shorter dwelling times, PICCs may offer a more economical option [62]. Furthermore, the paucity of cost-utility studies suggests that quality of life measures should also be considered alongside financial analyses to ensure that patient outcomes are optimized.

Collectively, this evidence suggests that while PICCs remain appropriate for short-term or less intensive therapy, PORTs provide superior safety and long-term reliability for patients undergoing extended chemotherapy courses.

This study presents certain limitations that should be acknowledged. To ensure a comprehensive comparison, we included data from RCTs and real-world evidence from observational (prospective or retrospective) studies, enabling the results to be applicable across controlled and practical settings. Experimental data often encounters challenges that can impact its reliability, such as the influence of learning curves, which reflect the time and experience required for practitioners to achieve proficiency in using new technologies or techniques [88,89]. Additionally, hospital-specific processes, including variations in protocols, resource availability, and staff expertise, can significantly affect outcomes. Incremental innovation further complicates the landscape, as small, progressive improvements in technology or methods may not be fully captured in isolated experimental studies. By integrating real-world data, these limitations can be mitigated, providing a more comprehensive and practical understanding of effectiveness in diverse clinical settings [90].

While the analysis encompassed various geographic contexts, it revealed a predominance of studies conducted in China and other highly developed regions. The high cancer incidence and extensive chemotherapy use in China might explain the widespread adoption of PICCs and PORTs for safe drug administration [91]. However, health-system differences in infrastructure, clinical practice, regulation, reimbursement, and costs, mean that evidence generated in China may not fully generalize to Western or lower-income contexts. Accordingly, these findings should be interpreted with caution when extrapolated to healthcare systems with different regulatory environments, resource allocation strategies, and spending capacities.

Moreover, only a limited proportion of the included studies (29%) directly compared outcomes between PICCs and PORTs. As a result, our findings are based on a comparison of summary estimates derived from independent meta-analyses rather than head-to-head trial data. This methodological approach allows a broader synthesis of the available evidence but inevitably introduces potential clinical and contextual variability between study populations, settings, and follow-up durations. Therefore, while consistent patterns emerged, suggesting lower complication rates with PORTs, the results should be interpreted as comparative trends rather than definitive evidence of superiority. Linked to this point, it should be noted that some clinical outcomes (PICC: infections, arterial puncture, mechanical malfunction, leakage; PORT local infections; PICC and PORT occlusion, malposition/movement, bleedings) were derived from a relatively small number of studies (ranging from one to three), which limits the precision and robustness of the pooled estimates. These results should therefore be interpreted with caution, and future multicenter studies are needed to strengthen and validate the current evidence.

The analyses revealed heterogeneity across studies for the clinical outcomes evaluated. This likely reflects differences in clinical indications and patient selection for the two devices: PICCs are often preferred for shorter or less intensive chemotherapy regimens, while PORTs are typically used in long-term treatment settings [85]. Additional contributors included variation in study design, patient case mix, catheter dwell time, insertion techniques, and clinical outcome definitions. To accommodate this variability, all meta-analyses were conducted using a random-effects model (maximum likelihood), which explicitly accounts for heterogeneity across studies.

This study was conducted as a targeted evidence synthesis (not a full Cochrane review); accordingly, we limited searching to PubMed/MEDLINE and Web of Science (Core Collection). Although this approach may have missed records not indexed in these sources (e.g. Embase, Scopus), the substantial overlap among major databases (for example, 99.11% of Web of Science journals are also indexed in Scopus [15]), together with more than 3000 records initially screened, makes it unlikely that broader searches would have materially altered our conclusions.

Another aspect that can be improved pertains to the overall quality of the studies under consideration. While none of the studies were classified as having poor quality, it is important to note that none demonstrated outstanding methodological rigor either. Although the group of studies with good quality reached the same conclusions as the overall group, future research requires more robust study designs, rigorous methodologies, and higher-quality evidence. Strengthening aspects such as study design, sample size, bias control, and statistical analysis could enhance the reliability and validity of findings, ultimately improving the overall standard of research in this field.

To better understand the clinical outcomes, healthcare resource utilization, and quality of life changes associated with both types of devices, further evidence is needed. Collecting comprehensive cost data, including materials, laboratory expenses, healthcare personnel, and patient-incurred costs, will offer a more complete view of the economic impact of these venous accesses. Incorporating these outcomes will provide a thorough evaluation, enhancing patient outcomes and promoting healthcare system sustainability. It is crucial to include a real-world perspective in these analyses, as RCTs are often limited in number, involve restricted patient populations and take place in controlled settings that may not accurately reflect real-world conditions. While RCTs are essential for establishing efficacy and safety in controlled environments, they may not fully capture the complexities and variations present in everyday clinical practice. Real-world studies, on the other hand, reflect diverse patient populations, varying healthcare settings, and practical treatment approaches. This broader perspective helps identify how interventions perform under routine conditions, revealing potential challenges, benefits, and areas for improvement that might be overlooked in RCTs. Additionally, real-world evidence supports the continuous assessment of healthcare technologies and practices, ensuring they remain relevant, effective, and sustainable. By integrating real-world data [92], healthcare systems can make more informed decisions, ultimately enhancing patient outcomes and fostering innovation in medical practices [90,93,94].

This evidence generation plan is crucial for gathering the necessary data to conduct future cost-effectiveness and budget impact analyses comparing PICCs with PORTs. Additionally, other dimensions of value, such as social and quality of life aspects, as well as broader implications for patients and caregivers, may also be assessed in parallel.

5. Conclusions

The present study provides updated evidence that may support the assessment of the cost-effectiveness profiles of PICCs and PORTs for the administration of oncological therapies. Conducting this analysis provides an opportunity to initiate evidence collection in this field, considering the implications of the recent European Health Technology Assessment (HTA) Regulation [95,96], which harmonizes clinical assessments of new drugs and medical devices across European member states, and the other initiatives at national and international level [97–99].

Based on the findings, PORTs offer advantages over PICCs. While PICCs may have lower initial insertion costs, PORTs could be more cost-effective in the long term due to lower complication rates and reduced overall healthcare costs. However, the choice between PICCs and PORTs should also take into account patient-specific factors, therapy duration, and hospital protocols.

Funding

This study was funded by Becton Dickinson UK Limited through an unrestricted grant to CERGAS SDA Bocconi School of Management. No interferences occurred in conducting the research project or writing the manuscript, for which the authors are solely responsible.

Declaration of interest

The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

Reviewer disclosures

Peer reviewers on this manuscript have no relevant financial relationships or otherwise to disclose.

Author contributions

Carla Rognoni contributed to the conception and design of the study and performed data collection and analysis. Baudolino Mussa and Rosanna Tarricone contributed to the interpretation of the results. Baudolino Mussa provided clinical expertise and critically revised the manuscript. Rosanna Tarricone provided scientific supervision of the study. Carla Rognoni drafted the manuscript, and all authors reviewed, edited, and approved the final version.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

ORCID

Carla Rognoni http://orcid.org/0000-0002-6330-0591
Baudolino Mussa http://orcid.org/0000-0002-0550-1002
Rosanna Tarricone http://orcid.org/0000-0002-2009-9357

References

1. Sudhakar S, Jacob A, Hegde NN, et al. Evaluation of chemotherapy infusion and phlebitis among cancer patients: a prospective observational single-center study. J Oncol Pharm Pract Off Publ Int Soc Oncol Pharm Pract. 2023;29(8):1944–1950. doi: 10.1177/10781552231161517
2. Fidalgo JAP, Fabregat LG, Cervantes A, et al. Management of chemotherapy extravasation: ESMO–EONS clinical practice guidelines†. Ann Oncol. 2012;23:vii167–vii173. doi: 10.1093/annonc/mds294
3. Kehagias E, Galanakis N, Tsetis D. Central venous catheters: which, when and how. Br J Radiol. 2023;96(1151):20220894. doi: 10.1259/bjr.20220894
4. Pittiruti M, Hamilton H, Biffi R, et al. ESPEN guidelines on parenteral nutrition: central venous catheters (access, care, diagnosis and therapy of complications). Clin Nutr. 2009;28(4):365–377. doi: 10.1016/j.clnu.2009.03.015
5. Kulkarni S, Wu O, Kasthuri R, et al. Centrally inserted external catheters and totally implantable ports for the delivery of chemotherapy: a systematic review and meta-analysis of device-related complications. Cardiovasc Intervent Radiol. 2014;37(4):990–1008. doi: 10.1007/s00270-013-0771-3
6. CDC. Background information: strategies for prevention of catheter-related infections in adult and pediatric patients [internet]. Infect. Control. 2024 [cited 2025 Mar 4]. Available from: https://www.cdc.gov/infection-control/hcp/intravascular-catheter-related-infection/prevention-strategies.html
7. Johansson E, Hammarskjöld F, Lundberg D, et al. A survey of the current use of peripherally inserted central venous catheter (PICC) in Swedish oncology departments. Acta Oncol Stockh Swed. 2013;52(6):1241–1242. doi: 10.3109/0284186X.2013.806820
8. Taxbro K, Hammarskjöld F, Thelin B, et al. Clinical impact of peripherally inserted central catheters vs implanted port catheters in patients with cancer: an open-label, randomised, two-centre trial. Br J Anaesth. 2019;122(6):734–741. doi: 10.1016/j.bja.2019.01.038
9. Rieger MJ, Schenkel X, Dedic I, et al. Complication rates of peripherally inserted central catheters vs implanted ports in patients receiving systemic anticancer therapy: a retrospective cohort study. Int J Cancer. 2023;153(7):1397–1405. doi: 10.1002/ijc.34612
10. Wang P, Soh KL, Ying Y, et al. Risk of VTE associated with PORTs and PICCs in cancer patients: a systematic review and meta-analysis. Thromb Res. 2022;213:34–42. doi: 10.1016/j.thromres.2022.02.024
11. Liu B, Wu Z, Lin C, et al. Applicability of TIVAP versus PICC in non-hematological malignancies patients: a meta-analysis and systematic review. PLOS ONE. 2021;16(8):e0255473. doi: 10.1371/journal.pone.0255473
12. Capozzi VA, Monfardini L, Sozzi G, et al. Peripherally inserted central venous catheters (PICC) versus totally implantable venous access device (PORT) for chemotherapy administration: a meta-analysis on gynecological cancer patients. Acta Bio-Medica Atenei Parm. 2021;92(5):e2021257.
13. Lin L, Li W, Chen C, et al. Peripherally inserted central catheters versus implantable port catheters for cancer patients: a meta-analysis. Front Oncol. 2023;13:1228092. doi: 10.3389/fonc.2023.1228092
14. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ [Internet]. 2009 [cited 2020 Apr 25];339(jul21 1):b2535–b2535. doi: 10.1136/bmj.b2535
15. Singh VK, Singh P, Karmakar M, et al. The journal coverage of web of science, Scopus and dimensions: a comparative analysis. Scientometrics. 2021;126(6):5113–5142. doi: 10.1007/s11192-021-03948-5
16. Cochrane Handbook for Systematic Reviews of Interventions [Internet]. [cited 2023 Dec 28]. Available from: https://training.cochrane.org/handbook/current
17. Payton ME, Greenstone MH, Schenker N. Overlapping confidence intervals or standard error intervals: what do they mean in terms of statistical significance? J Insect Sci. 2003;3(34):1–6. doi: 10.1673/031.003.3401
18. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health. 1998;52(6):377–384. doi: 10.1136/jech.52.6.377
19. Raath MIV, Chohan S, Wolkerstorfer A, et al. Clinical outcome measures and scoring systems used in prospective studies of port wine stains: a systematic review. PLOS ONE. 2020;15(7):e0235657. doi: 10.1371/journal.pone.0235657
20. RoB 2: a revised Cochrane risk-of-bias tool for randomized trials | Cochrane bias [Internet]. [cited 2025 Nov 7]. Available from: https://methods.cochrane.org/bias/resources/rob-2-revised-cochrane-risk-bias-tool-randomized-trials
21. ROBINS-I | Cochrane Bias [Internet]. [cited 2025 Nov 7]. Available from: https://methods.cochrane.org/bias/risk-bias-non-randomized-studies-interventions
22. Oualy HE, Hajji B, Omari M, et al. The complications of totally implantable central venous access ports: results from a prospective study in Morocco. J Med Surg Res. 2024;XI(1):1321–1326. doi: 10.46327/msrjg.1.000000000000256
23. Zhang X, Yin X. Comparative study of catheter structure types on venous thrombosis in cancer patients with peripherally inserted central catheters. Iran Red Crescent Med J [Internet]. 2023 [cited 2025 Jan 27]. doi: 10.32592/ircmj.2023.25.9.1991
24. Aghamohammadi D, Fakhari S, Bilehjani E, et al. Totally implantable venous access port infection in Northwest of Iran. Crescent J Med Biol Sci. 2017;4(3).
25. Anom TI, Rusdi, Sjaff AC, et al. Chemoport insertion as minimal chemotherapy access complications and forms of patient safety implementation goal. KnE Life Sci. 2018;4(9):348–351.
26. Iorio O, Gazzanelli S, D'Ermo G, et al. A prospective, comparative evaluation on totally implantable venous access devices by external jugular vein versus cephalic vein cutdown. Am Surg. 2018;84(6):841–843. doi: 10.1177/000313481808400629

27. Al-Asadi O, Almusarhed M, Eldeeb H. Predictive risk factors of venous thromboembolism (VTE) associated with peripherally inserted central catheters (PICC) in ambulant solid cancer patients: retrospective single centre cohort study. Thromb J. 2019;17(1):2. doi: 10.1186/s12959-019-0191-y
28. 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. doi: 10.1177/1179554919844770
29. Sun X, Xu J, Xia R, et al. Efficacy and safety of ultrasound-guided totally implantable venous access ports via the right innominate vein in adult patients with cancer: single-centre experience and protocol. Eur J Surg Oncol J Eur Soc Surg Oncol Br Assoc Surg Oncol. 2019;45(2):275–278. doi: 10.1016/j.ejso.2018.07.048
30. Bertoglio S, Cafiero F, Meszaros P, et al. PICC-PORT totally implantable vascular access device in breast cancer patients undergoing chemotherapy. J Vasc Access. 2020;21(4):460–466. doi: 10.1177/1129729819884482
31. Clemons M, Stober C, Kehoe A, et al. A randomized trial comparing vascular access strategies for patients receiving chemotherapy with trastuzumab for early-stage breast cancer. Support Care Cancer. 2020;28(10):4891–4899. doi: 10.1007/s00520-020-05326-y
32. Haggstrom L, Parmar G, Brungs D. Central venous catheter thrombosis in cancer: a multi-centre retrospective study investigating risk factors and contemporary trends in management. Clin Med Insights Oncol. 2020;14:1179554920953097. doi: 10.1177/1179554920953097
33. Liu Y, Xu L, Jiang M, et al. Chinesization of the quality of life assessment, venous device-port, and its reliability and validity tests for patients with breast cancer. J Vasc Access. 2020;21(6):983–989. doi: 10.1177/1129729820920528
34. Mehta N, Desai SM, Dhakad V, et al. External jugular cutdown technique for totally implantable venous access devices: a single-centre study. Indian J Surg Oncol. 2020;11(3):418–422. doi: 10.1007/s13193-020-01103-9
35. Sapkota S, Sannur R, Naik R. Analysis of peripherally inserted central catheter line in cancer patients: a single-center experience. South Asian J Cancer. 2020;9(4):253–256. doi: 10.1055/s-0040-1721175
36. Simonetti G, Sommariva A, Lusignani M, et al. Prospective observational study on the complications and tolerability of a peripherally inserted central catheter (PICC) in neuro-oncological patients. Support Care Cancer Off J Multinatl Assoc Support Care Cancer. 2020;28(6):2789–2795. doi: 10.1007/s00520-019-05128-x
37. Souadka A, Essangri H, Boualaoui I, et al. Supraclavicular versus infraclavicular approach in inserting totally implantable central venous access for cancer therapy: a comparative retrospective study. PLOS ONE. 2020;15(11):e0242727. doi: 10.1371/journal.pone.0242727
38. Taxbro K, Hammarskjöld F, Juhlin D, et al. Cost analysis comparison between peripherally inserted central catheters and implanted chest ports in patients with cancer-A health economic evaluation of the PICCPORT trial. Acta Anaesthesiol Scand. 2020;64(3):385–393. doi: 10.1111/aas.13505
39. Wang G-D, Wang H-Z, Shen Y-F, et al. The influence of venous characteristics on peripherally inserted central catheter-related symptomatic venous thrombosis in cancer patients. Cancer Manag Res. 2020;12:11909–11920.
40. Xu H, Chen R, Jiang C, et al. Implanting totally implantable venous access ports in the upper arm is feasible and safe for patients with early breast cancer. J Vasc Access. 2020;21(5):609–614. doi: 10.1177/1129729819894461
41. Yang Z, Li C, Liu W, et al. Complications and risk factors for complications of implanted subcutaneous ports for intraperitoneal chemotherapy in gastric cancer with peritoneal metastasis. Chin J Cancer Res Chung-Kuo Yen Cheng Yen Chiu. 2020;32(4):497–507. doi: 10.21147/j.issn.1000-9604.2020.04.07
42. Ye F, Liu Y, Yu P, et al. Intraoperative ipsilateral subclavian port catheter implantation in resectable breast cancer patients: a novel, safe, and convenient clinical practice. Cancer Med. 2020;9(23):8970–8978. doi: 10.1002/cam4.3595
43. Yin L, Li J. Central venous catheter insertion in colorectal cancer patients, PICC or PC? Cancer Manag Res. 2020;12:5813–5818.
44. Burbridge B, Lim H, Dwernychuk L, et al. Comparison of the quality of life of patients with breast or colon cancer with an arm vein port (TIVAD) versus a peripherally inserted central catheter (PICC). Curr Oncol Tor Ont. 2021;28(2):1495–1506. doi: 10.3390/curroncol28020141
45. Corti F, Brambilla M, Manglaviti S, et al. Comparison of outcomes of central venous catheters in patients with solid and hematologic neoplasms: an Italian real-world analysis. Tumori. 2021;107(1):17–25. doi: 10.1177/0300891620931172
46. Kim H, Kwon S, Son SM, et al. Tailored approach to the choice of long-term vascular access in breast cancer patients. PLOS ONE. 2021;16(7):e0255004. doi: 10.1371/journal.pone.0255004
47. Li P, Sun X, Tang J, et al. Efficacy analysis and hemodynamic changes of hematological system diseases after PICC chemotherapy. Eur Rev Med Pharmacol Sci. 2021;25(21):6566–6572.
48. Mittal GS, Sundriyal D, Naik NB, et al. Totally implantable venous access device (Chemoport) in oncology: study of 168 polyurethane Chemoport catheter system. South Asian J Cancer. 2021;10:261–264. doi: 10.1055/s-0041-1739041
49. Piredda A, Radice D, Zencovich C, et al. Safe use of peripherally inserted central catheters for chemotherapy of solid malignancies in adult patients: a 1-year monocentric, prospectively-assessed, unselected cohort of 482 patients. J Vasc Access. 2021;22(6):873–881. doi: 10.1177/1129729820962905
50. Sun X, Bai X, Zhang Y, et al. Perioperative and postoperative complications of ultrasound-guided totally implantable venous access ports via the brachiocephalic vein in patients with cancer: a prospective study. J Cancer. 2021;12(5):1379–1385. doi: 10.7150/jca.55343
51. Wu O, McCartney E, Heggie R, et al. Venous access devices for the delivery of long-term chemotherapy: the CAVA three-arm RCT. Health Technol Assess Winch Engl. 2021;25(47):1–126. doi: 10.3310/hta25470
52. Yun W-S, Yang S-S. Comparison of peripherally inserted central catheters and totally implanted venous access devices as chemotherapy delivery routes in oncology patients: a retrospective cohort study. Sci Prog. 2021;104(2):368504211011871. doi: 10.1177/00368504211011871
53. Ben Jdidia I, Zribi K, Daldoul A, et al. Complications of catheters with an implantable chamber: about 26 cases. Ann Pharm Fr. 2022;80(6):803–809. doi: 10.1016/j.pharma.2022.04.001
54. Chen YB, Bao HS, Hu TT, et al. Comparison of comfort and complications of implantable venous access port (IVAP) with ultrasound guided internal jugular vein (IJV) and axillary vein/subclavian vein (AxV/SCV) puncture in breast cancer patients: a randomized controlled study. BMC Cancer. 2022;22(1):248. doi: 10.1186/s12885-022-09228-6
55. Kartsouni V, Moschouris H, Bersimis F, et al. Complications of totally implantable central venous catheters (ports) inserted via the internal jugular vein under ultrasound and fluoroscopy guidance in adult oncology patients: a single-center experience. Cureus. 2022;14(7):e27485. doi: 10.7759/cureus.27485
56. Lakshmi HN, Sharma M, Jain A, et al. Chemoport fracture due to catheter pinch off syndrome: a rare complication of subclavian vein approach revisited. Indian J Surg Oncol. 2022;13(2):343–347. doi: 10.1007/s13193-021-01459-6
57. McKeown C, Ricciuti A, Agha M, et al. A prospective study of the use of central venous catheters in patients newly diagnosed with acute myeloid leukemia treated with induction chemotherapy. Support Care Cancer Off J Multinatl Assoc Support Care Cancer. 2022;30(2):1673–1679. doi: 10.1007/s00520-021-06339-x
58. Pénichoux J, Rio J, Kammoun L, et al. Retrospective analysis of the safety of peripherally inserted catheters versus implanted port catheters during first-line treatment for patients with diffuse large B-cell lymphoma. Eur J Haematol. 2022;109(1):41–49. doi: 10.1111/ejh.13767
59. Sacks OA, Chugh P, He K, et al. Survival and complications after placement of central venous access ports for palliative

chemotherapy: a single-institution retrospective analysis. Am J Hosp Palliat Care. 2022;39(1):34–38. doi: 10.1177/10499091211002127
60. Salawu K, Arowojolu O, Afolaranmi O, et al. Totally implantable venous access ports and associated complications in sub-saharan Africa: a single-centre retrospective analysis. Ecancermedicalscience. 2022;16:1389. doi: 10.3332/ecancer.2022.1389
61. Shao G, Zhou X, Zhang S, et al. Cost-utility analysis of centrally inserted totally implanted access port (PORT) vs. peripherally inserted central catheter (PICC) in the oncology chemotherapy. Front Public Health. 2022;10:942175. doi: 10.3389/fpubh.2022.942175
62. Wang K, Zhou Y, Huang N, et al. Peripherally inserted central catheter versus totally implanted venous port for delivering medium- to long-term chemotherapy: a cost-effectiveness analysis based on propensity score matching. J Vasc Access. 2022;23(3):365–374. doi: 10.1177/1129729821991360
63. Bolgeo T, Di Matteo R, Crivellari S, et al. Quality of life in patients with PICC diagnosed with mesothelioma: results of a multicenter epidemiological survey (LifePICC). J Vasc Access. 2023;26(1):217–227. doi: 10.1177/11297298231202046
64. Chen N, Yang Q, Li YF, et al. Cost-utility analysis of different venous access devices in breast cancer patients: a decision-based analysis model. BMC Health Serv Res. 2023;23(1):497. doi: 10.1186/s12913-023-09517-1
65. Chrisanthopoulou P, Iconomou G, Assimakopoulos K, et al. Health-related quality of life in patients with solid tumors receiving implantable venous access ports for chemotherapy: a prospective randomized controlled trial. Eur J Oncol Nurs Off J Eur Oncol Nurs Soc. 2023;67:102445. doi: 10.1016/j.ejon.2023.102445
66. Erdemir A, Rasa HK. Impact of central venous port implantation method and access choice on outcomes. World J Clin Cases. 2023;11(1):116–126. doi: 10.12998/wjcc.v11.i1.116
67. Erişen MA, Yılmaz FÖ. Comparison of chemotherapy treatment administration via venous port and peripheral vascular access in terms of quality of life and costs. Qual Life Res Int J Qual Life Asp Treat Care Rehabil. 2023;32(7):1897–1908. doi: 10.1007/s11136-023-03365-6
68. Ghosh S, Joseph B, Jain A, et al. The external jugular vein cut-down method for chemoport insertion from a tertiary cancer treatment center in Central India: a prospective study. Gulf J Oncolog. 2023;1(43):40–45.
69. Liu R, Xu H, Pu L, et al. Clinical characteristics of peripherally inserted central catheter-related complications in cancer patients undergoing chemotherapy: a prospective and observational study. BMC Cancer. 2023;23(1):894. doi: 10.1186/s12885-023-11413-0
70. Abdurrahman Tünay AA. Evaluation of subclavian central venous port catheters placed by anesthesiologists: single-center experience [internet]. Istanbul Med J. 2023 [cited 2025 Jan 27]. Available from: https://istanbulmedicaljournal.org/articles/evaluation-of-subclavian-central-venous-port-catheters-placed-by-anesthesiologists-single-center-experience/doi/imj.galenos.2023.92972
71. Abou-Mrad A, Marano L, Oviedo RJ. A monocentric analysis of implantable ports in cancer treatment: five-year efficacy and safety evaluation. Cancers (Basel). 2024;16(16):2802. doi: 10.3390/cancers16162802
72. 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(3):102391.
73. Farsiani F, Tayebi P, Parsa M, et al. The laterality of port catheter placement in breast cancer patients: investigating the impact of side selection. Indian J Surg Oncol [Internet]. 2024 [cited 2025 Jan 27];16(1):344–348. doi: 10.1007/s13193-024-02095-6
74. Heggie R, Jaiswal N, McCartney E, et al. Central venous access devices for the delivery of systemic anticancer therapy: an economic evaluation. Value Health. 2024;27(1):7–14. doi: 10.1016/j.jval.2023.09.2996
75. Kumar V, Sringeri R. Our experience of 500 chemo port placements with cephalic vein cut down technique-A saviour for cancer treatment. Indian J Surg Oncol. 2024;15(4):784–788. doi: 10.1007/s13193-024-02000-1
76. Kee Wei L, Cheong CS, Gin GG. Peripherally inserted central venous catheter-related complications in adult patients with haematological malignancy. Malays J Med Sci MJMS. 2024;31(2):52–61. doi: 10.21315/mjms2024.31.2.6
77. Lu A, Hu M, Qi X, et al. A retrospective cohort study of implantable venous access port-related and peripherally inserted central catheter-related complications in patients with hematological malignancies in China. Sage Open Med. 2024;12:20503121241257190. doi: 10.1177/20503121241257190
78. Melo-Pinto D, Moreira-Marques T, Guerreiro E, et al. Totally implantable venous access devices: a restrospective analysis of morbidity and risk factors in a hospital with multi-technique approaches. Surg Pract Sci. 2024;16:100237. doi: 10.1016/j.sipas.2024.100237
79. Nie S, Wang L, Ma S, et al. Trends in the prevalence and risk factors for peripherally inserted central catheter-related complications in cancer patients from 2016 to 2022: a multicenter study. Support Care Cancer. 2024;32(4):239. doi: 10.1007/s00520-024-08444-z
80. Pinelli F, Barbani F, Defilippo B, et al. Quality of life in women with breast cancer undergoing neoadjuvant chemotherapy: comparison between PICC and PICC-port. Breast Cancer Tokyo Jpn. 2024;31(5):945–954. doi: 10.1007/s12282-024-01608-z
81. Sharma V, Pandey A. A spectrum of chemoport-associated complications and their management in cancer patients. Cureus. 2024;16(4):e58052. doi: 10.7759/cureus.58052
82. Wang M, Tang L, Xu R, et al. Clinical application of ultrasound-guided totally implantable venous access ports implantation via the posterior approach of the internal jugular vein. J Chin Med Assoc JCMA. 2024;87(1):126–130. doi: 10.1097/JCMA.0000000000001030
83. Wang P, He L, Yuan Q, et al. Risk factors for peripherally inserted central catheter-related venous thrombosis in adult patients with cancer. Thromb J. 2024;22(1):6. doi: 10.1186/s12959-023-00574-4
84. Jamison DT, Breman JG, Measham AR, et al., editors. Disease control priorities in developing countries [internet]. 2nd ed. (WA) (DC): The International Bank for Reconstruction and Development/The World Bank; 2006 [cited 2023 Dec 27]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK11728/
85. Sousa B, Furlanetto J, Hutka M, et al. Central venous access in oncology: ESMO clinical practice guidelines. Ann Oncol Off J Eur Soc Med Oncol. 2015;26(Suppl 5):v152–v168. doi: 10.1093/annonc/mdv296
86. Qiu J, Huang S, Wen P, et al. Implantable port catheters versus peripherally inserted central catheters for cancer patients requiring chemotherapy: an RCT-Based meta-analysis. J Cancer. 2025;16(4):1127–1136. doi: 10.7150/jca.103631
87. Kalma B, van Zundert A. Perils of the PICC: peripherally inserted central catheter-associated complications and recommendations for prevention in clinical practice—A narrative review. Healthcare. 2025;13(16):1993. doi: 10.3390/healthcare13161993
88. Tarricone R, Amatucci F, Armeni P, et al. Establishing a national HTA program for medical devices in Italy: overhauling a fragmented system to ensure value and equal access to new medical technologies. Health Policy. 2021;125(5):602–608. doi: 10.1016/j.healthpol.2021.03.003
89. Tarricone R, Callea G, Ogorevc M, et al. Improving the methods for the economic evaluation of medical devices. Health Econ. 2017;26(Suppl S1):70–92. doi: 10.1002/hec.3471
90. Tarricone R, Boscolo PR, Armeni P. What type of clinical evidence is needed to assess medical devices? Eur Respir Rev Off J Eur Respir Soc. 2016;25(141):259–265. doi: 10.1183/16000617.0016-2016
91. Han B, Zheng R, Zeng H, et al. Cancer incidence and mortality in China, 2022. J Natl Cancer Cent. 2024;4(1):47–53. doi: 10.1016/j.jncc.2024.01.006
92. Murphy LA, Akehurst R, Solà-Morales O, et al. Structure and content of a taxonomy to support the use of real-world evidence by health technology assessment practitioners and healthcare decision makers. Value Health. 2023;26(4):20–31. doi: 10.1016/j.jval.2023.01.007

93. Pongiglione B, Torbica A, Blommestein H, et al. Do existing real-world data sources generate suitable evidence for the HTA of medical devices in Europe? Mapping and critical appraisal. Int J Technol Assess Health Care. 2021;37(1):e62. doi: 10.1017/S0266462321000301
94. Berger ML, Sox H, Willke RJ, et al. Good practices for real-world data studies of treatment and/or comparative effectiveness: recommendations from the joint ISPOR-ISPE special task force on real-world evidence in health care decision making. Value Health J Int Soc Pharmacoeconomics Outcomes Res. 2017;20(8):1003–1008. doi: 10.1016/j.jval.2017.08.3019
95. Regulation on Health Technology Assessment - European Commission [Internet]. 2024 [cited 2024 Aug 6]. Available from: https://health.ec.europa.eu/health-technology-assessment/regulation-health-technology-assessment_en
96. Tarricone R, Banks H, Ciani O, et al. An accelerated access pathway for innovative high-risk medical devices under the new European Union medical devices and health technology assessment regulations? Analysis and recommendations. Expert Rev Med Devices. 2023;20(4):259–271. doi: 10.1080/17434440.2023.2192868
97. World Health Organization. Health technology assessment of medical devices. Éval Technol Santé Dispos Médicaux. 2011. p. 44.
98. The International Network of Agencies for Health Technology Assessment [Internet]. INAHTA; [cited 2025 Feb 14]. Available from: https://www.inahta.org/
99. Salute M della. Il Programma nazionale di HTA dei dispositivi medici [Internet]. [cited 2024 Sep 27]. Available from: https://www.salute.gov.it/portale/dispositiviMedici/dettaglioContenutiDispositiviMedici.jsp?lingua=italiano&id=5201&area=dispositivi-medici&menu=tecnologie