Complications of implanted port catheters and peripherally inserted central catheters in chemotherapy-treated cancer patients: A meta-analysis

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Abstract

Background. One of the most significant advancements in nursing technology for cancer patients has been the development of implantable port catheters and peripherally inserted central venous catheters. They create an essential, dependable route for subjects to receive chemotherapy, long-term infusions and nutritional care, and provide a site for regular blood draws.

Objectives. We performed a meta-analysis to evaluate the complications of implanted port catheters and peripherally inserted central catheters in chemotherapy-treated cancer patients.

Materials and methods. A systematic literature search up to April 2022 was performed and a total of 11,801 articles have been retrieved. Of these, 5017 concerned peripherally inserted central catheters and 6784 implanted port catheters to administer chemotherapy. Odds ratios (ORs) and mean differences (MDs) with 95% confidence intervals (95% CIs) were calculated to assess the complications of implanted port catheters and peripherally inserted central catheters in chemotherapy-treated cancer patients using dichotomous and contentious methods with random- or fixed-effects models.

Results. Peripherally inserted central catheters had significantly higher incidence of occlusion complications (OR: 5.43, 95% CI: 3.46–8.52, $p < 0.001$), longer durations of local infection (OR: 2.94, 95% CI: 2.17–4.00, $p < 0.001$), higher incidence of catheter-related infection (OR: 2.13, 95% CI: 1.19–3.83, $p = 0.01$), higher rate of malposition (OR: 6.46, 95% CI: 2.93–14.27, $p < 0.001$), higher rates of catheter-related thrombosis (OR: 2.71, 95% CI: 1.90–3.87, $p < 0.001$), higher incidence of phlebitis complications (OR: 6.67, 95% CI: 2.94–15.11, $p < 0.001$), higher incidence of accidental removal (OR: 3.38, 95% CI: 1.97–5.81, $p < 0.001$), and a shorter catheter lifespan (MD: –233.16, 95% CI: –449.52––16.80, $p = 0.03$) in subjects undergoing chemotherapy compared to those in whom implanted port catheters were used.

Conclusions. Implantable port catheter has advantages over peripherally inserted central catheter in decreasing cancer patients' complications. The outcomes provide evidence for practitioners to select which type of central venous catheters is better for cancer chemotherapy subject.

Key words: cancer treatment using chemotherapy, malposition complications, catheter-related thrombosis, peripherally inserted central catheters

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Introduction

The 2nd most common cause of death worldwide is cancer. In China, more than 6 million new cancer cases are diagnosed each year. It is anticipated that the number of cancer patients is going to increase as the environmental and lifestyle factors change. Chemotherapy is frequently used in cancer treatment and can increase the survival times of patients suffering from metastatic cancers.[1] Many chemotherapy agents are administered intravenously and can cause harm to peripheral blood vessels. Central venous access is preferred over peripheral vascular access because recurrent venipunctures can cause discomfort for patients.[2] In cancer patients receiving chemotherapy, central venous access offers a higher level of security and comfort. The 2 most common infusion routes for chemotherapy are peripherally inserted central venous catheters and implanted port catheters.[3] Peripherally inserted central venous catheters, which are central venous catheters placed in the brachial, basilic or cephalic veins, were first developed in the 1970s. In the 1980s, implanted port catheters were developed. These are inserted into the subclavian vein to serve as a port for intravenous access without the use of external catheter lines. One of the most significant developments in nursing technology for cancer patients has been the development of implanted port catheters and peripherally inserted central venous catheters. They create an essential, dependable path for patients to receive chemotherapy, long-term infusions and nutritional care, and provide a site for regular blood draws. As a result, nurses frequently ask about the comparative risks and benefits of these 2 options.[2] Patient safety and increasing cost awareness are major concerns in healthcare. Therefore, research is frequently centered on comparing the safety of these 2 popular infusion catheters.[4] Medical decision-makers require more data to thoroughly assess the risks and financial advantages of these 2 types of medical equipment. However, the preference for central venous catheter in terms of safety is not supported by any solid or definitive research. The extent to which these 2 catheters are used differs by nation, with doctors more likely to advise subjects to have a peripherally inserted central venous catheter. The reason for their popularity may be their non-inferior complication rates as compared to the implanted port catheters, and the fact that they are less expensive to implant than the implanted port catheters.[5] However, research has indicated that the long-term maintenance expenses of peripherally inserted central venous catheters may be even higher than those of implanted port catheters.[6] According to one study, peripherally inserted central venous catheters have a higher incidence of complications than implanted port catheters (32.8%).[7] However, in another observational study, complications during 106 intravenous catheterizations were equally common using both techniques.[8] Occlusion, infection, malposition, catheter breakage, catheter-associated thrombosis, extravasation, phlebitis, pneumothorax, and inadvertent removal rates are the most frequent catheter-related problems occuring in consequence of using peripherally implanted central venous catheters and implanted port catheters.[9]

Objectives

There is a dearth of information to help doctors and patients decide which catheters are the best choice in a given situation. To improve clinical decision-making, this meta-analysis compares the complications of implanted port catheters and peripherally inserted central catheters in chemotherapy-treated cancer patients.

Materials and methods

Information sources

The main goals of the current meta-analysis were to evaluate the effect of complications for implanted port catheters and peripherally inserted central catheters in chemotherapy-treated cancer patients. All included studies were conducted in humans. Study size or language had no bearing on inclusion. Review articles, comments and research that failed to provide a measure of the association were all excluded from the study. Figure 1 depicts a flowchart of our study. When the following inclusion criteria were satisfied, the publications were included in the meta-analysis. The meta-analysis encompassed studies:

1. Performed as either a prospective, observational, randomized controlled, or retrospective study;

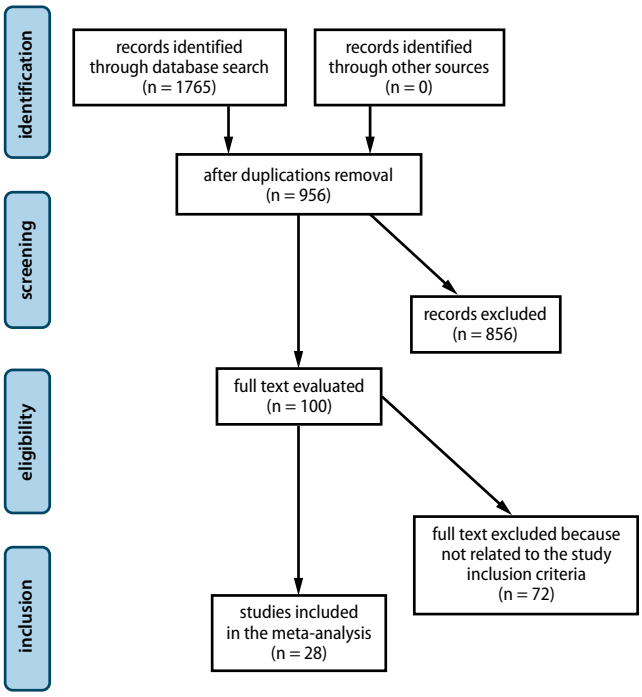

Fig. 1. Flowchart of the study process

Table 1. Search strategy for each database

Database	Search strategy
PubMed	#1 "cancer using chemotherapy" [MeSH terms] OR "peripherally placed central catheters" [all fields] OR "occlusion complications" [all fields] OR "catheter-related thrombosis" [all fields] #2 "implanted port catheters" [MeSH terms] OR "cancer using chemotherapy" [all fields] OR "catheter-related thrombosis" [all fields] OR "occlusion complications" [all fields] OR "malposition complications" [all fields] #3 #1 AND #2
Embase	#1 "cancer using chemotherapy"/exp OR "peripherally placed central catheters"/exp OR "occlusion complications"/exp OR "catheter-related thrombosis" #2 "implanted port catheters"/exp OR "occlusion complications"/exp OR "malposition complications"/exp OR "catheter-related thrombosis" #3 #1 AND #2
Cochrane Library	#1 "cancer using chemotherapy": ti, ab, kw [OR] "peripherally placed central catheters": ti, ab, kw OR "occlusion complications": ti, ab, kw (word variations have been searched) #2 "catheter-related thrombosis": ti, ab, kw OR "implanted port catheters": ti, ab, kw OR "occlusion complications": ti, ab, kw OR "malposition complications": ti, ab, kw OR "catheter-related thrombosis": ti, ab, kw (word variations have been searched) #3 #1 AND #2

MeSH – medical subject headings; ti, ab, kw – terms in the title, abstract or keyword field; exp – exploded indexing term.

2. Enrolling chemotherapy-treated cancer patients;
3. Relying on implanted port catheters and peripherally inserted central catheters for the intervention regimen;
4. Comparing implanted port catheters to peripherally inserted central catheters.

Studies that did not examine the effects of peripherally inserted central catheters and implanted port catheters in cancer patients receiving chemotherapy, research on patients treated without implanted port catheters or peripherally inserted central catheters, and studies where the significance of comparing the 2 outcomes was not emphasized were excluded.

Search strategy

According to the PICOS concept,[10,11] a protocol of search techniques was created and defined as follows: P (population): chemotherapy-treated cancer patients; I (intervention/exposure): peripherally inserted central catheters and implanted port catheters; C (comparison): peripherally inserted central catheters compared to implanted port catheters; O (outcome): occlusion complications, duration of local infections at puncture sites, catheter-related infection, complications of malpositioning, catheter-related thrombosis, phlebitis complications, accidental removal, and catheter lifespan; S (study design): no restriction.[12]

First, we carried out a thorough search of Ovid, Embase, Cochrane Library, PubMed, and Google Scholar databases up until March 2022 using a combination of keywords and related terms for cancer such as: chemotherapy, peripherally inserted central catheters, implanted port catheters, malposition complications, catheter-related thrombosis, occlusion complications, length of local infection, phlebitis complications, accidental removal, and catheter lifespan, as shown in Table 1. To exclude studies that did not document a relationship between peripherally inserted central catheters and implanted port catheters, all recruited studies were compiled into an EndNote (Clarivate, London, UK) file, duplicates were eliminated, and the titles and abstracts were checked and reviewed.

Data collection process

The data were condensed based on the following criteria: study- and subject-related characteristics in a standardized form, first author's last name, study period, publication year, country, region, population type, clinical and treatment characteristics, categories, qualitative and quantitative methods of evaluation, information source, outcome evaluation, and statistical analysis.[13]

Data items

When there were varying results from a single study on the impact of complications of peripherally inserted central catheters and implanted port catheters on chemotherapy-treated cancer patients, the data were collected separately.

Study risk of bias assessment

The 2 authors separately examined the methodological quality of the selected research to determine the likelihood of bias in the individual studies. The methodological quality was evaluated using the "risk of bias" instrument from the Cochrane Handbook for Systematic Reviews of Interventions v. 5.1.0.[14] Each study was graded according to the evaluation criteria and classified based on one of the 3 risk levels of bias: low – all quality criteria were satisfied; moderate – one or more quality criteria were partially satisfied or unclear; or high – one or more of the criteria were not met or not included. Reevaluations of the original articles were performed to fix any inconsistencies.

Effect measures

Sensitivity studies were performed on studies that reported and examined the influence of peripherally inserted central catheters compared to implanted port catheters. The comparisons between peripherally inserted central catheters and implanted port catheters were used for sensitivity and subclass analyses.

Synthesis methods

The current meta-analysis used a random- or fixed-effect model with dichotomous techniques to compute the odds ratio (OR) and mean difference (MD), with a 95% confidence interval (95% CI). An I^2 index ranging from 0 to 100% was calculated. Values of around 0%, 25%, 50%, and 75% showed no, low, moderate, and high heterogeneity, respectively.[15] A random effect was considered if the I^2 index was 50% or higher. If the I^2 index was less than 50%, the likelihood of employing fixed influences increased.[15] However, additional characteristics that show a high degree of similarity between the included studies were analyzed to confirm the employment of the correct model. By stratifying the initial evaluation on the previously mentioned outcome categories, a subcategory analysis was completed. For the current analysis, the statistical significance for the differences between subcategories was defined as a p-value of 0.05.

Reporting bias assessment

The publication bias was assessed qualitatively and quantitatively using funnel plots of the logarithms of ORs compared to their standard errors (SEs) and the Egger's regression test (the publication bias was considered present if the p-value was 0.05).[11]

Certainty assessment

Two-tailed tests were used to calculate all p-values. The Reviewer Manager v. 5.3 was used to provide the statistical analyses and graphs (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark).

Results

Out of the 1765 relevant studies, a total of 28 articles published between 2010 and 2022 matched our inclusion criteria and were included in the meta-analysis.[4,16–42] Table 2 displays the data from these research studies. The chosen studies encompassed 11,801 chemotherapy-treated cancer patients. Of these, 5017 were using peripherally inserted central catheters and 6784 were using implanted port catheters. At the commencement of this meta-analysis, there were 392,970 examined individuals in total. Sixteen studies presented data grouped according to the occlusion complications, 11 presented data grouped according to the duration of local infections at the puncture sites, 18 according to the catheter-related infections, 7 according to malposition complications, 17 according to catheter-related thrombosis, 8 according to phlebitis complications, 9 according to accidental removal, and 5 according to catheter lifespan.

Peripherally inserted central catheters had a significantly higher risk of occlusion complications (OR: 5.43, 95% CI: 3.46–8.52, $p < 0.001$) with low heterogeneity ($I^2 = 31\%$), a longer duration of local infections at the puncture sites (OR: 2.94, 95% CI: 2.17–4.00, $p < 0.001$) with low heterogeneity ($I^2 = 49\%$), higher incidence of catheter-related infections (OR: 2.13, 95% CI: 1.19–3.83, $p = 0.01$) with moderate heterogeneity ($I^2 = 57\%$), higher incidence of malposition complications (OR: 6.46, 95% CI: 2.93–14.27, $p < 0.001$) with no heterogeneity ($I^2 = 4\%$), higher rates of catheter-related thrombosis (OR: 2.71, 95% CI: 1.90–3.87, $p < 0.001$) with moderate heterogeneity ($I^2 = 35\%$), higher incidence of phlebitis complications (OR: 6.67, 95% CI: 2.94–15.11, $p < 0.001$) with low heterogeneity ($I^2 = 25\%$), higher incidence of accidental removal (OR: 3.38, 95% CI: 1.97–5.81, $p < 0.001$) with no heterogeneity ($I^2 = 0\%$), and shorter catheter lifespans (MD: –233.16, 95% CI: –449.52 – –16.80, $p = 0.03$) with high heterogeneity ($I^2 = 100\%$) compared to implanted port catheters, as shown in Fig. 2–9.

Due to the limited data published for these variables, it was not possible to adjust for individual factors such as gender, age and ethnicity in stratified models to explore the impact of these factors on comparison outcomes. Visual inspection of funnel plots and quantitative measures using the Egger's regression test revealed no evidence of publication bias ($p = 0.89$). However, it was discovered that the majority of the included randomized controlled trials were of poor methodological quality, had no bias in selective reporting and included rather sparse outcome data.

Discussion

This meta-analysis included 11,801 chemotherapy-treated cancer patients. Of these, 5017 were using peripherally inserted central catheters and 6784 had implanted port catheters.[4,16–42] Peripherally inserted central catheters had significantly higher incidence of occlusion complications, longer duration of local infections at puncture sites, higher incidence of catheter-related infections, higher incidence of malposition complications, higher incidence of catheter-related thrombosis, higher incidence of phlebitis complications, higher incidence of accidental removals, and shorter catheter lifespans compared to implanted port catheters.

A total of 28 cohort studies with more than 10,000 chemotherapy-treated cancer patients studied were included in this study. Practitioners should choose the appropriate type of catheter based on the subject's physical conditions,

Table 2. Characteristics of the studies selected for the meta-analysis

Study	Country	Total	Peripherally inserted central catheters	Implantable port catheters
Rotzinger et al. 2017[4]	Switzerland	2568	791	1777
Revel-Vilk et al. 2010[16]	Israel	314	188	126
Kim et al. 2010[17]	South Korea	96	24	72
Jain et al. 2013[18]	India	123	98	25
Patel et al. 2014[19]	Australia	70	36	34
Viart et al. 2015[20]	France	123	98	25
Bratton et al. 2014[21]	USA	144	34	110
Liu 2017[22]	China	298	120	178
Martella et al. 2015[23]	Italy	102	45	57
Coady et al. 2015[24]	UK	39	9	30
Wang 2016[25]	China	110	60	50
Lefebvre et al. 2016[26]	France	448	158	290
Verboom et al. 2017[27]	Netherlands	112	10	102
Fang et al. 2017[28]	China	105	60	45
Lu 2017[29]	China	550	214	336
Tang 2014[30]	China	2970	1509	1461
Vashi et al. 2017[31]	USA	202	191	11
Taxbro et al. 2019[32]	Sweden	369	201	168
Clemons et al. 2020[33]	Canada	48	25	23
Yin and Li 2020[34]	China	763	65	698
Clatot et al. 2020[35]	France	253	126	127
Wang et al. 2022[36]	China	276	138	138
Burbridge et al. 2021[37]	Canada	101	50	51
Yun and Yang 2021[38]	South Korea	467	185	282
Comas et al. 2022[39]	Spain	525	292	233
Zhang et al. 2022[40]	China	96	48	48
Pénichoux et al. 2022[41]	France	479	213	266
McKeown et al. 2022[42]	USA	50	29	21
Total		11,801	5017	6784

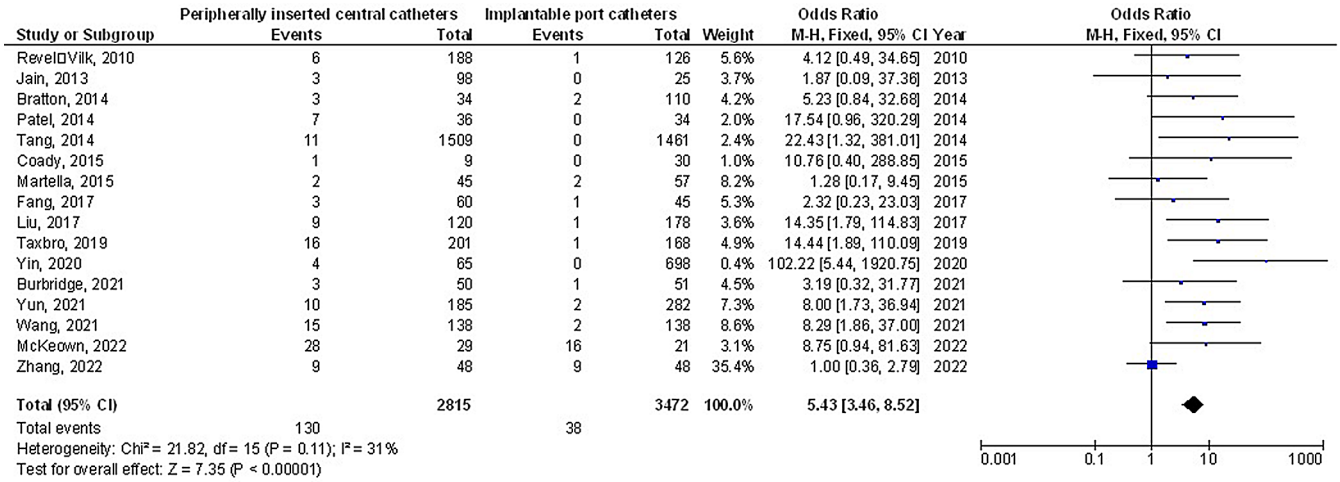

Fig. 2. Forest plot of peripherally inserted central catheters compared to implanted port catheters influence on occlusion complications

df – degrees of freedom; 95% CI – 95% confidence interval.

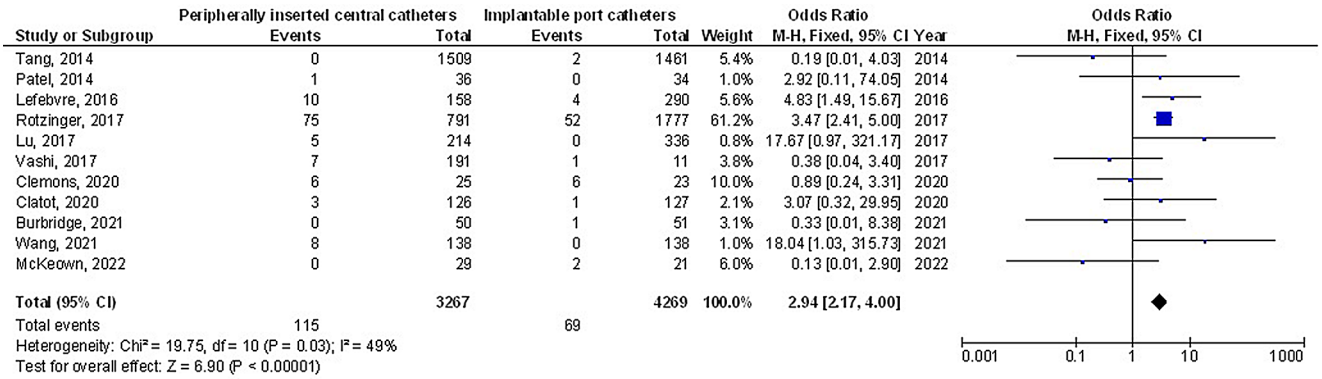

Fig. 3. Forest plot of peripherally inserted central catheters compared to implanted port catheters influence on the length of local infections at puncture sites

df – degrees of freedom; 95% CI – 95% confidence interval.

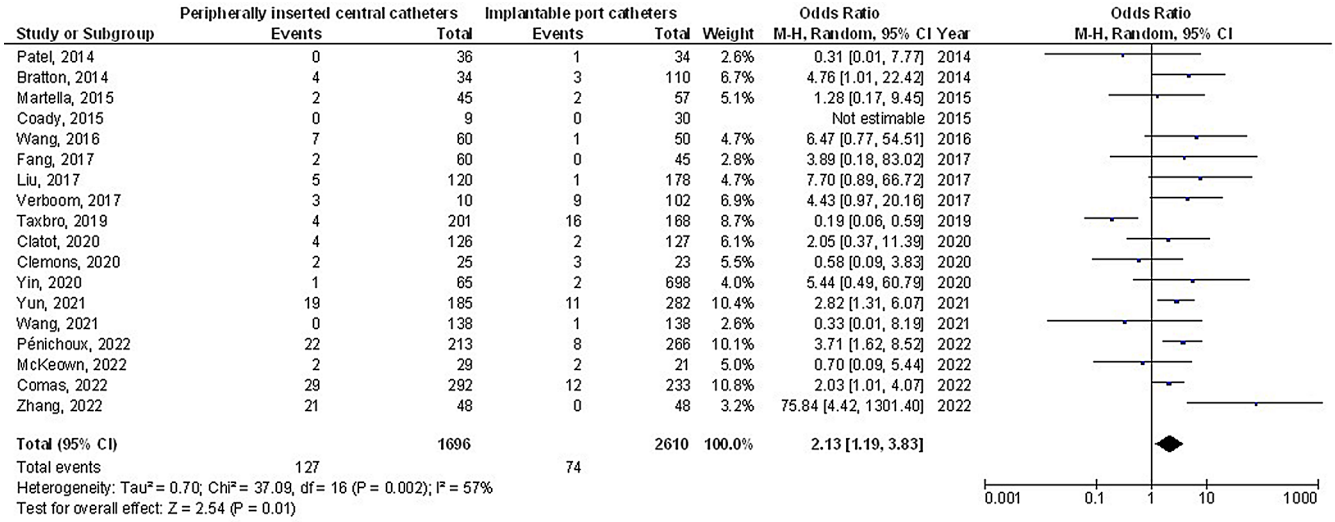

Fig. 4. Forest plot of peripherally inserted central catheters compared to implanted port catheters influence on catheter-related infections

df – degrees of freedom; 95% CI – 95% confidence interval.

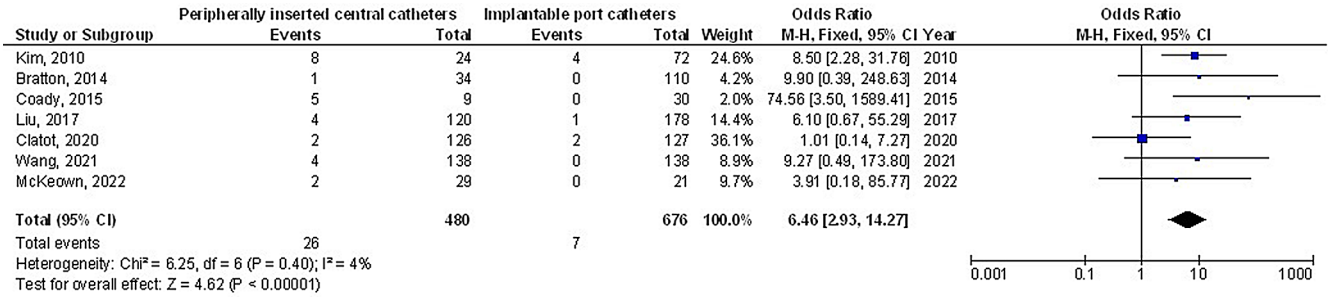

Fig. 5. Forest plot of peripherally inserted central catheters compared to implanted port catheters influence on malposition complications

df – degrees of freedom; 95% CI – 95% confidence interval.

the catheter lifespan, the incidence of complications, and other criteria.[17] The shorter lifespan of the peripherally inserted central venous catheters compared to implantable port catheters may have been the result of higher complication rates associated with peripherally inserted central venous catheters and the higher unintentional removal rate.[43] A peripherally implanted central venous catheter can be left in place for several months (even for a year), as stated in the Infusion Therapy Standards of Practice from 2021.[44] However, numerous studies have demonstrated that if nurses adhere to maintenance practices, an implanted port catheter can be utilized for several years.[45] Additionally, the use of an implanted port catheter spares subjects receiving treatment for longer than a year the discomfort brought on by frequent punctures. When comparing peripherally implanted central

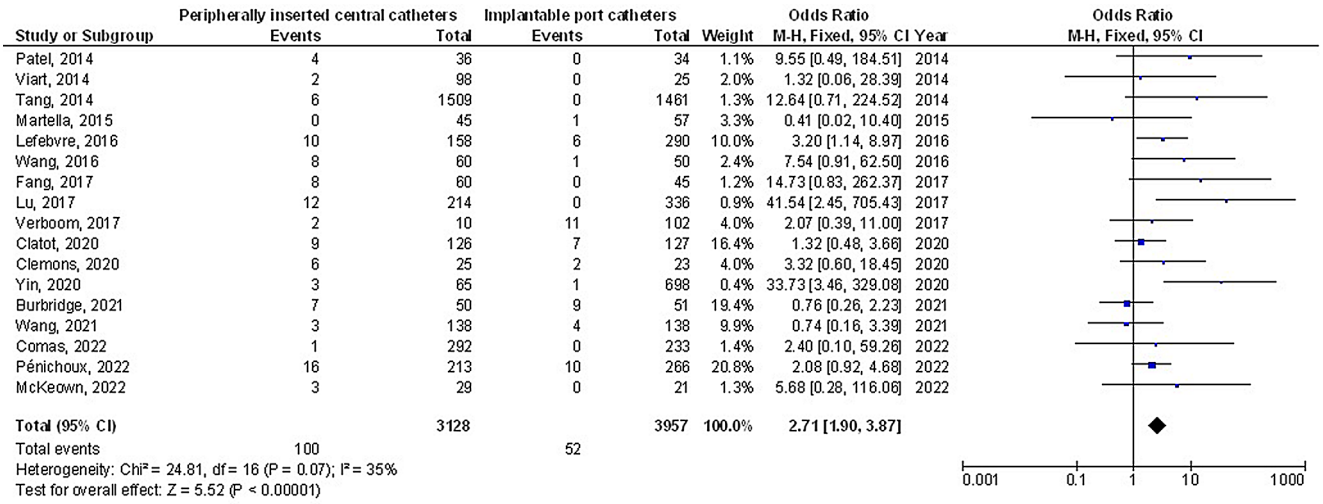

Fig. 6. Forest plot of peripherally inserted central catheters compared to implanted port catheters influence on rates of catheter-related thrombosis

df – degrees of freedom; 95% CI – 95% confidence interval.

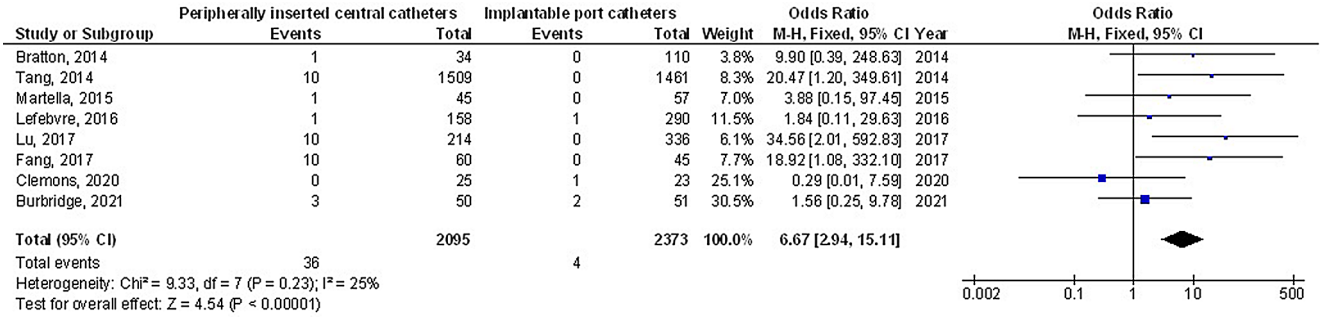

Fig. 7. Forest plot of peripherally inserted central catheters compared to implanted port catheters influence on phlebitis

df – degrees of freedom; 95% CI – 95% confidence interval.

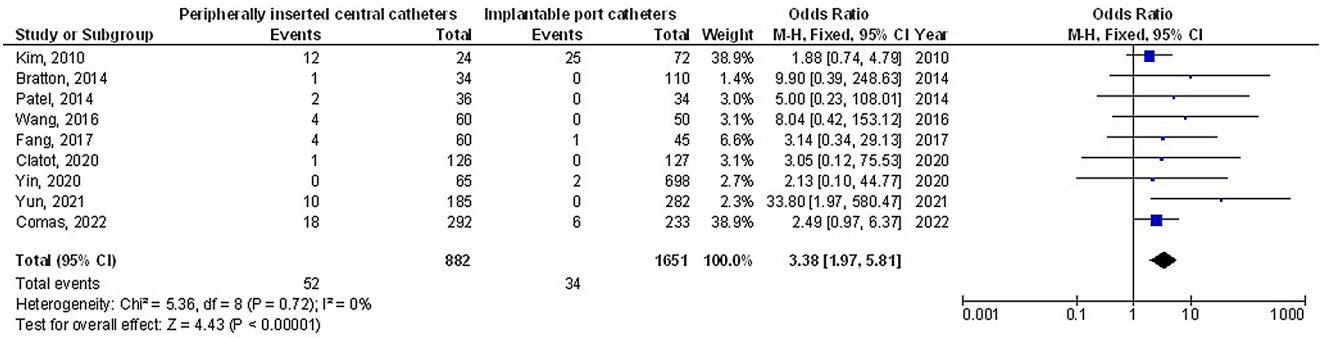

Fig. 8. Forest plot of peripherally inserted central catheters compared to implanted port catheters influence on accidental removal rates

df – degrees of freedom; 95% CI – 95% confidence interval.

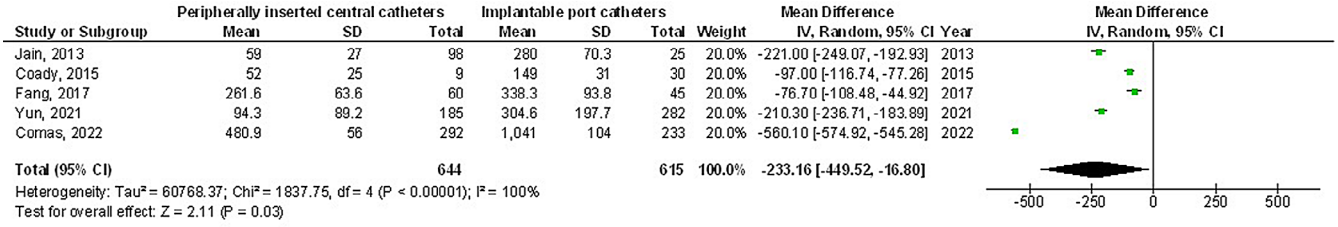

Fig. 9. Forest plot of peripherally inserted central catheters compared to implanted port catheters influence on a catheter's lifespan

df – degrees of freedom; 95% CI – 95% confidence interval; SD – standard deviation.

venous catheters to implantable port catheters, the overall incidence of all 7 problems considered in this study was higher. The risk of thrombosis and vessel or line obstruction was increased by the presence of cancer and the chemotherapy agents administered through the central venous catheters.[46] This meta-analysis showed that implanted port catheters had a lower incidence of central venous catheter thrombosis and occlusion compared to peripherally inserted catheters. Similar findings were reported in a another systematic evaluation of risk variables for catheter-related thrombosis in cancer patients.[47] Possible explanations include the fact that peripherally inserted central venous catheter subjects require a longer length of catheter for vessel entry, whereas the shorter path of implantable port catheters causes comparatively minor stimulation to the vessel walls as it enters the blood vessels. The mechanical stimulus to the vascular endothelial cells of a foreign substance may encourage the activation of thrombotic factors, leading to vessel blockage. Moreover, this study demonstrated that compared to central venous catheters implanted peripherally, the incidence of implantable port catheter malposition, extravasation, phlebitis, and unintentional removal was decreased. The implantable port catheter base, which is anchored to the chest wall, might offer a more stable access point that is seldom influenced by upper limb movements. On the other hand, the insertion point for a peripherally implanted central venous catheter is frequently in the arm and is more likely to migrate with vigorous exercise, upper limb activity or even everyday mobility. According to our subgroup analysis findings, the incidence of peripherally inserted central venous catheter infections was higher compared to implantable port catheters. According to the research by Bouza et al., the skin (65%) and catheter or catheter joints (30%) are the most common entry points for infections (15%).[48] A peripherally inserted central venous catheter has an external section through which skin microbes may migrate into the blood, or more importantly, the subcutaneous areas, raising the possibility of infection. In contrast, the puncture seat and catheter of the implantable port catheters are implanted completely under the skin, without any portion of the device exposed. Additionally, difficulties with peripherally implanted central venous catheters seem to be more severe than those with implanted port catheters, which results in higher treatment expenditures. Therefore, it is easy to understand why implanted port catheters have lower long-term costs than those of peripherally inserted central venous catheters, which is consistent with the findings of a cost analysis conducted by Patel et al.[19]

This meta-analysis demonstrates how peripherally positioned central catheters and implanted port catheter problems can affect chemotherapy-treated cancer patients.[49–54] Further research is still required to clarify these potential complications as well as to assess the impact of peripherally positioned central catheters compared to implanted port catheters on the outcomes under investigation. Larger, more homogeneous samples are required for such research studies. These conclusions were also reported in a previous study, which used a similar meta-analysis method and revealed similarly encouraging results for peripherally inserted central catheters in terms of lowering puncture site infections and alleviating occlusion consequences.[55–62] Since our meta-analysis was unable to determine whether differences in age and ethnicity are related to the results, well-conducted randomized controlled trials are required to evaluate these factors as well as the effect of different gender, age, ethnicity, and other variables.

Limitations

Since so many papers were not included in the meta-analysis, there might have been a selection bias. However, the excluded papers did not meet the requirements for inclusion in our meta-analysis. The sample size for 6 of the 28 chosen papers was less than 100. Additionally, we were unable to determine whether or not the outcomes were influenced by age and ethnicity. The study was undertaken to evaluate the impact of complications associated with peripherally inserted central catheters and implanted port catheters on chemotherapy-treated cancer patients. Data from the studies used may have introduced bias due to missing or incorrect information. The respondents' nutritional status, as well as the characteristics of age, sex and gender were all potential sources of bias.

Conclusions

Peripherally inserted central catheters had significantly higher incidence of occlusion complications, longer durations of local infections at puncture sites, higher incidence of catheter-related infection, higher malposition complications, higher rates of catheter-related thrombosis, higher incidence of phlebitis complications, higher accidental removals, and shorter catheter lifespans compared to implanted port catheters. The small sample size of 6 studies in the meta-analysis and the small number of studies evaluating many of the comparisons require care when analyzing the results.

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