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Laparoscopic Versus Open Insertion of Peritoneal Dialysis Catheters in Pediatric Patients: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Peritoneal dialysis (PD) is frequently preferred for pediatric patients with end-stage renal disease due to its feasibility for home care and superior quality of life. Proper placement of the Tenckhoff catheter is critical for PD success, yet catheter-related complications remain a major concern. Laparoscopic techniques have gained popularity due to enhanced visualization and potential for adjunctive procedures, which may enhance catheter longevity.
Objective: To compare the effectiveness and safety of laparoscopic versus open surgical placement of Tenckhoff catheters in pediatric patients.
Methods: A systematic review and meta-analysis were conducted according to PRISMA guidelines. PubMed, EMBASE, and Cochrane were searched through May 2025. Eligible studies compared laparoscopic and open PD catheter placement in patients under 18 years. Odds ratios (ORs) were calculated using random-effects models. Risk of bias was assessed using ROBINS-I.
Results: Nine observational studies comprising 659 patients were included (laparoscopy: 288; open surgery: 371). Laparoscopic placement significantly reduced the odds of reoperation (OR = 0.28; 95 % CI: 0.08–0.97; p = 0.0444) and peritonitis (OR = 0.21; 95 % CI: 0.09–0.52; p = 0.0006). The pooled analysis of all outcomes also favored the laparoscopic approach (OR = 0.55; 95 % CI: 0.33–0.90; p = 0.0175). No significant differences were observed for catheter migration, obstruction, exit-site infection/tunnel infection and pericatheter leakage.
Conclusions: Laparoscopic catheter insertion is associated with lower risks of reoperation and peritonitis and may be considered the preferred approach. Further prospective, randomized studies are warranted to confirm these benefits.

1. Introduction

Peritoneal Dialysis (PD) is frequently the preferred modality of renal replacement therapy in pediatric patients with end-stage renal disease (ESRD), primarily due to its feasibility for home-based management, preservation of vascular access, and better quality of life compared to hemodialysis [1,2]. The success of PD largely depends on the proper placement and sustained functionality of the Tenckhoff catheter, which serves as the conduit for dialysate exchange. Nevertheless, catheter-related complications, including peritonitis, migration, obstruction, exit-site infection/tunnel infection and leakage, remain significant causes of technique failure, morbidity, hospitalization, and conversion to hemodialysis, which can be distressing in this patient population [3,4].

Multiple techniques are available for Tenckhoff catheter implantation, including percutaneous, open surgical, and laparoscopic approaches. For decades, the open surgical technique has been widely used due to its technical simplicity and cost-

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effectiveness. However, laparoscopic catheter insertion has emerged as a valuable alternative, offering minimally invasive access and improved visualization of the peritoneal cavity. Since its introduction in the early 1990s, laparoscopy has gained increasing acceptance in both adult and pediatric populations [5].

Laparoscopic insertion techniques can be categorized as basic, where visualization is used primarily to confirm catheter position, or advanced, which incorporates adjunctive procedures designed to optimize catheter function and reduce complications. These may include rectus sheath tunneling, omentopexy, adhesiolysis, and procedures addressing anatomic variants such as epiploic appendage resection, salpingectomy, or colopexy. These techniques aim to enhance catheter longevity and reduce malfunction by minimizing the risk of migration and obstruction [5].

Several observational studies in pediatric patients have reported reduced rates of complications such as catheter malfunction and infections with the laparoscopic method [6–14]. However, evidence remains conflicting, and no consensus has been established regarding the optimal surgical technique for this population.

Given the heterogeneity of existing data and the absence of randomized controlled trials in children, this systematic review and meta-analysis aims to compare laparoscopic versus open surgical placement of Tenckhoff catheters in pediatric patients undergoing peritoneal dialysis. Our objective is to assess differences in key outcomes such as reoperation rates, catheter malfunction, peritonitis, exit-site infection/tunnel infection, obstruction and migration, thereby providing evidence to inform clinical decision-making.

2. Methods

2.1. Search strategy

A systematic search was performed in PubMed, EMBASE, and the Cochrane Central Register of Controlled Trials (CENTRAL) from inception through May 2025. The search strategy was developed using the PICOTT framework and combined Medical Subject Headings (MeSH) with relevant free-text terms, including: “peritoneal dialysis,” “laparoscopic,” “open,” “laparotomy,” “Tenckhoff,” and “pediatric patients.” No restrictions were applied regarding language or publication status. Reference lists of all included studies and relevant reviews were also screened manually to identify additional eligible studies. Three reviewers (MMC, LC, KS) independently screened the titles, abstracts, and full texts for inclusion. Discrepancies were resolved by consensus.

2.2. Selection criteria

Inclusion in this meta-analysis was restricted to studies that met all the following eligibility criteria: (1) retrospective or prospective comparative design; (2) compared laparoscopic and open surgical approaches; (3) involved pediatric patients (<18 years) undergoing peritoneal dialysis catheter placement; (4) reported postoperative outcomes; and (5) were published in any language. Studies were excluded if they: (1) included only adult populations, or mixed adult and pediatric populations when pediatric data were not reported separately; (2) lacked a comparator group; (3) were case reports or case series with fewer than 10 patients; (4) involved overlapping populations; or (5) were review articles, editorials, or conference abstracts without full data access.

2.3. Data extraction

Three reviewers (MMC, MLM and KS) independently extracted data from each included study using a standardized data collection form, including study design, patient demographics, surgical technique, follow-up periods, and postoperative outcomes (catheter migration, catheter obstruction, reoperation, peritonitis, exit-site infection/tunnel infection and pericatheter leakage). Discrepancies were resolved by consensus. Extracted information included: study characteristics (author, year, country, design); population details (sample size, age, sex, group allocation); type of surgical technique (laparoscopic or open approach); use of omentectomy; and number of events for each postoperative outcome (catheter migration, catheter obstruction, pericatheter leakage, peritonitis, exit-site infection/tunnel infection, reoperation).

When outcomes were reported as percentages, absolute event counts were calculated based on the reported group sizes. In cases where the number of events exceeded the number of patients, suggesting recurrent episodes, the number of events was conservatively adjusted to match the number of individual patients. Outcomes were grouped by type and synthesized by comparing the laparoscopic and open groups for each outcome. Only outcomes reported by at least three studies were considered for pooled analysis.

2.4. Methodological quality assessment

The methodological quality and risk of bias of the included non-randomized comparative studies were independently assessed by two reviewers (MLM, LC) using the ROBINS-I tool (Risk Of Bias In Non-randomized Studies - of Interventions). Each study was evaluated across seven domains: confounding, participant selection, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of reported results. Studies were categorized as having low, moderate, serious, or critical risk of bias. Publication bias was assessed using funnel plot asymmetry and Egger's regression test.

2.5. Statistical analysis

This meta-analysis was performed using the R statistical software (version 4.4.3) with the metafor and meta packages, in accordance with the PRISMA guidelines and Cochrane Collaboration methodology. A two-tailed p-value <0.05 was considered statistically significant. For dichotomous outcomes, odds ratios (ORs) and 95 % confidence intervals (CIs) were calculated using the DerSimonian and Laird random-effects model. Heterogeneity across studies was assessed using the I^2 statistic and between-study variance (τ^2). An $I^2 > 50$ % was considered to represent substantial heterogeneity.

Forest plots were generated for each outcome. Funnel plots were constructed to evaluate potential publication bias when at least three studies were available, and Egger's regression test was used to formally assess asymmetry. Leave-one-out sensitivity analyses were performed to evaluate the influence of individual studies on the pooled effect size. Additionally, a post hoc power analysis including all reported outcomes was conducted to assess the statistical power of the observed effect sizes.

2.6. Protocol registration

This systematic review was prospectively registered in the PROSPERO international database of systematic reviews (registration number: CRD420251078677).

3. Results

3.1. Study search

We retrieved 389 records from three electronic databases and identified an additional 226 studies through reference lists and manual searching. After removing 385 duplicates, 230 records remained. Based on title and abstract screening, 217 studies were excluded. We assessed the full texts of the remaining 13 articles for eligibility and excluded four due to ineligible interventions or comparison groups (n = 1) and non-pediatric populations (n = 3). A total of nine studies [6–14] met the inclusion criteria and were included in this meta-analysis. Figure 1 illustrates the study selection process.

3.2. Characteristics of studies

A total of 9 studies were included in this meta-analysis, comprising 659 pediatric patients who underwent peritoneal dialysis catheter insertion: 288 (43.7 %) in the laparoscopic group and 371 (56.2 %) in the open surgery group. All included studies were observational in design (retrospective cohort studies); no randomized controlled trials were identified.

The included populations were exclusively pediatric (<18 years), with study sample sizes ranging from 29 to 173 patients, with follow-up durations ranging from less than 1 month to 12.5 years. The majority of patients were male, although gender distribution was inconsistently reported across studies.

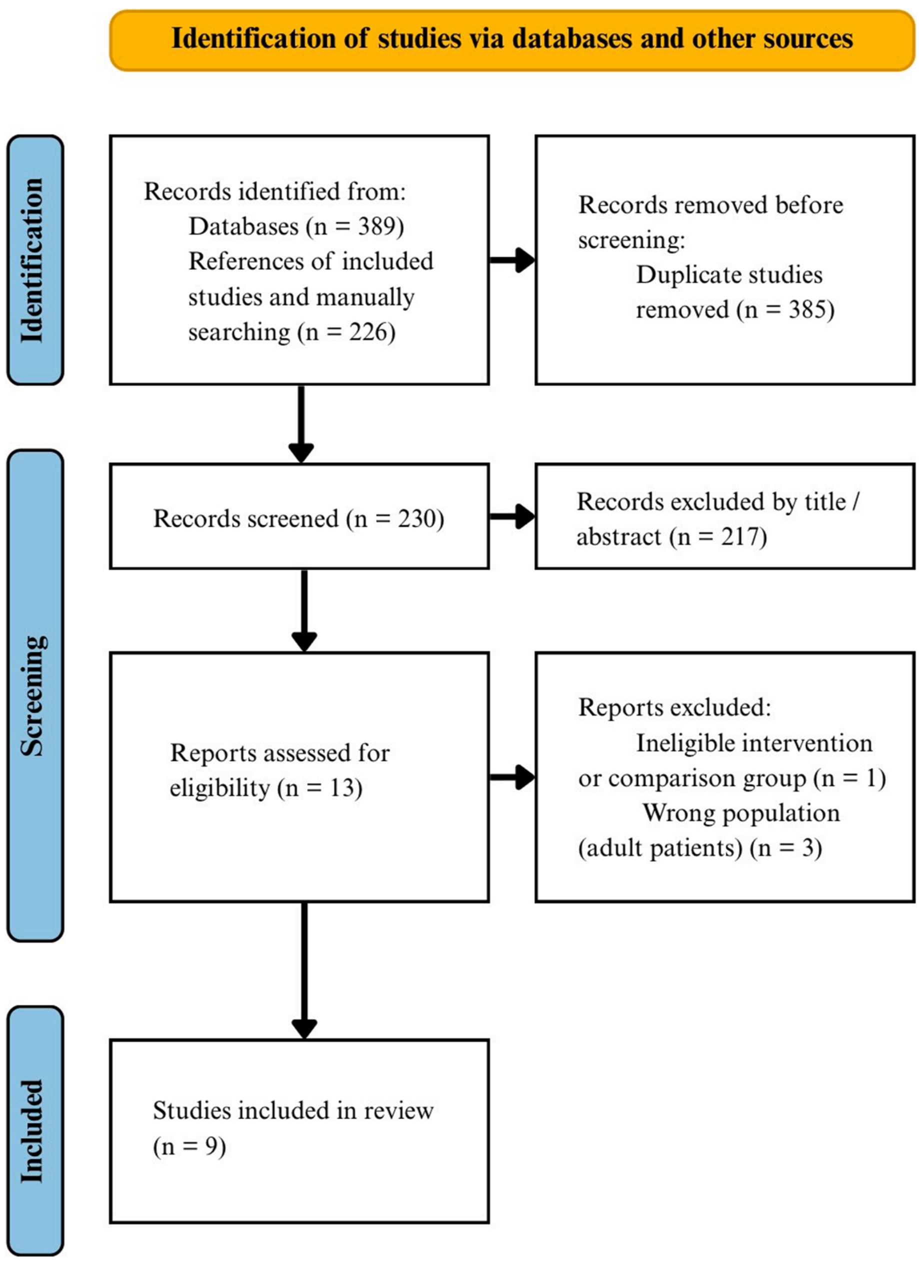

Fig. 1. PRISMA flow diagram of study retrieval and selection. Databases reported in this figure included PubMed, EMBASE, and the Cochrane Library.

Catheter placement techniques varied across studies, with most laparoscopic approaches involving two or three port techniques with or without omentectomy. In the open surgery group, mini-laparotomy through a lower quadrant incision was the most commonly described method. However, not all studies provided detailed intraoperative technique descriptions.

Baseline characteristics are summarized in Table 1. All included studies reported at least one of the following postoperative outcomes: catheter migration, catheter obstruction, peritonitis, exit-site infection/tunnel infection, pericatheter leakage, or need for reoperation. However, not all outcomes were consistently reported across studies, and definitions varied slightly between articles.

3.3. Pooled analysis of all outcomes

A pooled analysis combining all reported outcomes demonstrated a statistically significant reduction in overall adverse events in the laparoscopic group compared to the open surgery group (OR = 0.55; 95 % CI: 0.33–0.90; $p = 0.0175$). Heterogeneity was moderate ($I^2 = 61.1$ %). These findings suggest that laparoscopic catheter placement may be associated with a lower overall risk of complications. The pooled analysis of all outcomes considered the following postoperative complications: catheter migration, catheter obstruction, peritonitis, exit-site infection/tunnel infection, pericatheter leakage, and need for reoperation. Figure 2 displays the corresponding forest plot.

3.4. Meta-analysis of reoperation

Among the eligible studies, five studies [7,10,11,13,14], compared the reoperation rates between the laparoscopic and open surgery groups. Meta-analysis demonstrated a statistically significant reduction in the odds of reoperation in the laparoscopic group ($I^2 = 80.5$ %; $\tau^2 = 1.5661$; OR = 0.28; 95 % CI: 0.08–0.97; $p = 0.0444$). Figure 3 depicts the forest plot of reoperation.

Higher reoperation rates in the open surgery group were mainly due to catheter malfunction or malposition, omental wrapping, or hernia formation, as reported by Wong et al. and Carpenter et al. [7,11]. These complications were mitigated in laparoscopic approaches that included omentectomy and PPV closure.

3.5. Meta-analysis of peritonitis

Peritonitis was reported in six eligible studies [6,10–14], including a total of 128 patients in the laparoscopic group and 242 in the open surgery group. Meta-analysis revealed a significantly lower odds of peritonitis in patients who underwent laparoscopic catheter placement compared to open surgery ($I^2 = 0$ %; $\tau^2 = 0$; OR = 0.21; 95 % CI: 0.09–0.52; $p = 0.0006$). Figure 4 depicts the forest plot of peritonitis.

3.6. Meta-analysis of catheter migration

A total of four studies [8,10,11,13] investigated the differences regarding catheter migration rates between the laparoscopic and open surgery groups. The pooled odds ratio showed no significant difference between laparoscopic and open approaches ($I^2 = 31.5$ %; $\tau^2 = 0.3771$; OR = 0.80; 95 % CI: 0.25–2.55; $p = 0.7112$), indicating comparable risk of catheter migration. Figure 5 depicts the forest plot of catheter migration.

3.7. Meta-analysis of catheter obstruction

Six eligible studies [6,9–11,13,14] reported catheter obstruction rates in the laparoscopic and open surgery groups. Pooled analysis found no statistically significant difference between laparoscopic and open techniques regarding catheter obstruction ($I^2 = 43.1$ %; $\tau^2 = < 0.0001$; OR = 1.28; 95 % CI: 0.62–2.65; $p = 0.4988$). Figure 6 depicts the forest plot of catheter obstruction.

3.8. Meta-analysis of exit-site infection/tunnel infection

Exit-site and tunnel infection were reported in five eligible studies [6,10,12–14], encompassing a total of 95 patients in the laparoscopic group and 210 in the open surgery group. The pooled analysis showed no statistically significant difference between the groups ($I^2 = 30$ %; $\tau^2 = 0.9706$; OR = 0.96; 95 % CI: 0.22–4.13; $p = 0.9565$), indicating that the surgical approach did not alter the odds of catheter infection. Figure 7 depicts the forest plot of exit-site infection/tunnel infection.

3.9. Meta-analysis of pericatheter leakage

A total of six studies [6,9,10,12–14] evaluated the incidence of pericatheter leakage. The pooled analysis did not demonstrate a statistically significant difference between laparoscopic and open approaches ($I^2 = 33.2$ %; $\tau^2 = 0.6236$; OR = 0.66; 95 % CI: 0.23–1.84; $p = 0.4252$). Figure 8 depicts the forest plot of pericatheter leakage.

3.10. Quality assessment

Risk of bias was assessed using the ROBINS-I tool for non-randomized studies. All nine included studies were retrospective cohort designs and were judged to have a serious overall risk of bias. The most frequent domain contributing to this judgment was confounding, primarily due to the absence of statistical adjustment for baseline differences between the laparoscopic and open surgery groups. Additional concerns included missing outcome

Table 1
Characteristics of the studies comparing laparoscopic and open peritoneal catheter dialysis insertion.

Author	Year	Country	Study type	Laparoscopic group (n)	Open surgery group (n)	Median age (years) Laparoscopic group	Median age (years) Open surgery group	Follow-up
Stack	2016	New Zealand	Retrospective cohort study	31	71	2	0.3	<31 days
Copeland	2008	USA	Retrospective cohort study	27	23	10.8	9.9	Not reported
Biçakci	2016	Turkey	Retrospective cohort study	16	33	11.6	12.1	4 years
Daschner	2002	Germany	Retrospective cohort study	22	20	6.9	3.2	12.5 years
Carpenter	2016	USA	Retrospective cohort study	51	122	11.4	9.0	19 months
Sanabria	2023	Colombia	Retrospective cohort study	69	23	7.6	7.6	3.5 years
Mattioli	2007	Italy	Retrospective cohort study	15	14	14.2	13.4	13–14 months
Wong	2020	China	Retrospective cohort study	33	32	10	10.5	4–15 months
Lindley	2012	UK	Retrospective cohort study	10	23	2.8	7.7	Not reported

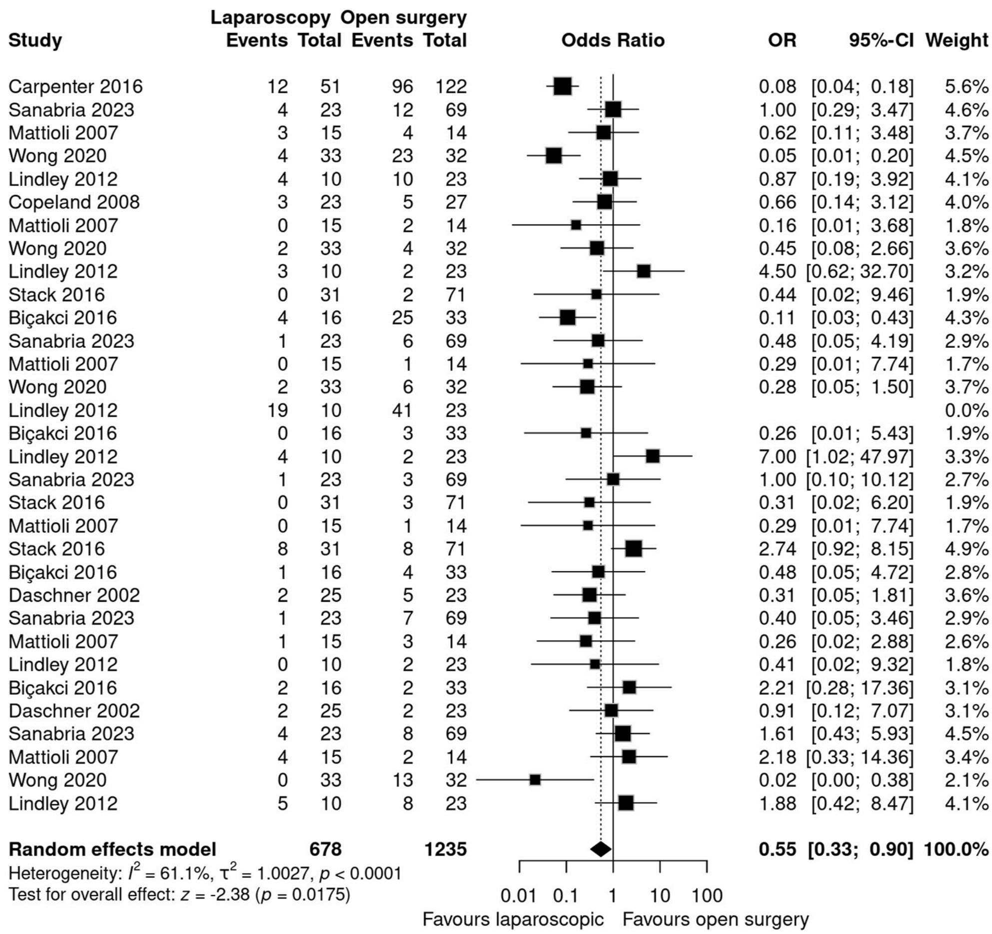

Fig. 2. Forest plot of pooled analysis of all outcomes between the laparoscopic and open surgery groups. In this graph, squares represent point estimates for individual studies, with black horizontal lines representing 95 % confidence intervals, and diamonds represent aggregated results. The width of the diamond represents the 95 % con dence interval, and the center of the diamond represents the point estimate. It indicates that laparoscopic surgery is associated with lower risk of postoperative complications.

data and potential bias in the selection of reported results. A summary of the domain-level and overall risk of bias assessments is presented in Fig. 9.

To assess the risk of publication bias, funnel plots were visually inspected and Egger's test was performed for all outcomes. For the pooled analysis of all outcomes, the funnel plot demonstrated notable asymmetry, although Egger's test did not reach statistical significance ($p = 0.3748$). Among individual outcomes, reoperation ($p = 0.2311$), peritonitis ($p = 0.1833$), and catheter migration ($p = 0.1215$) showed no evidence of publication bias on Egger's test. However, for catheter infection ($p = 0.0125$) and pericatheter leakage ($p = 0.0326$), Egger's test indicated significant funnel plot asymmetry, suggesting possible small-study effects or under-reporting of negative findings. The visual inspection of these plots corroborated the statistical findings. Taken together, these results indicate that publication bias may be present for some outcomes, particularly those with fewer studies and higher heterogeneity. This limitation should be considered when interpreting the strength of the evidence. The funnel plots for the pooled analysis and each individual outcome are provided as Supplementary Fig. S1–S7.

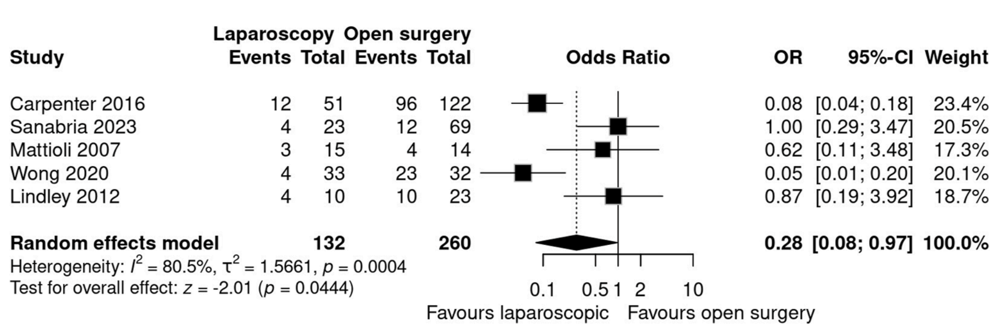

Fig. 3. Forest plot of reoperation rates between the laparoscopic and open surgery groups. It indicates that laparoscopic surgery is associated with lower risk of reoperation.

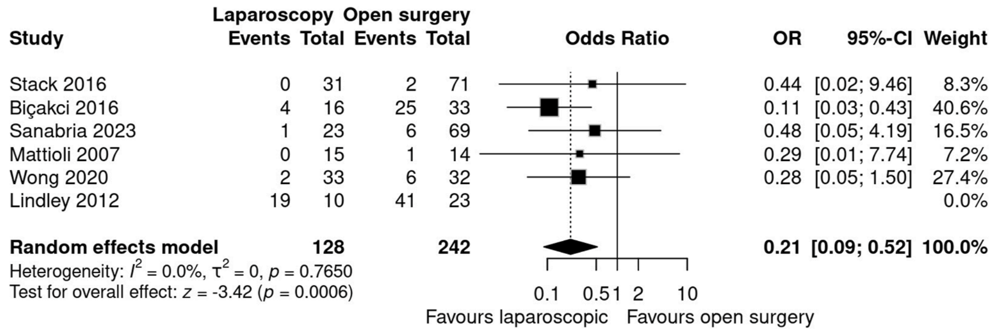

Fig. 4. Forest plot of peritonitis rates between the laparoscopic and open surgery groups. It indicates that laparoscopic surgery is associated with lower risk of peritonitis.

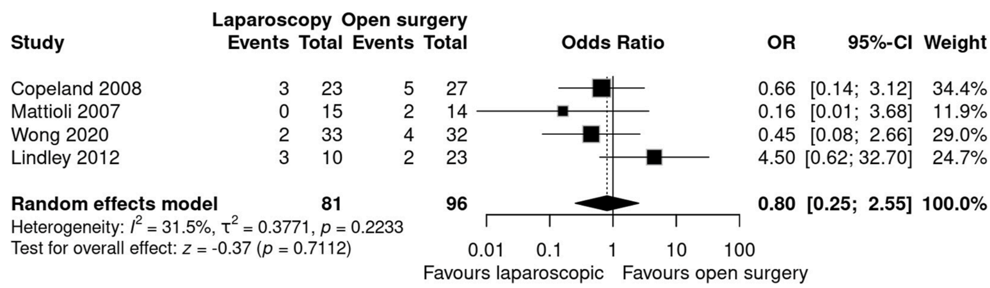

Fig. 5. Forest plot of catheter migration rates between the laparoscopic and open surgery groups. It indicates no statistically significant difference between the risk of catheter migration in laparoscopic vs open surgery.

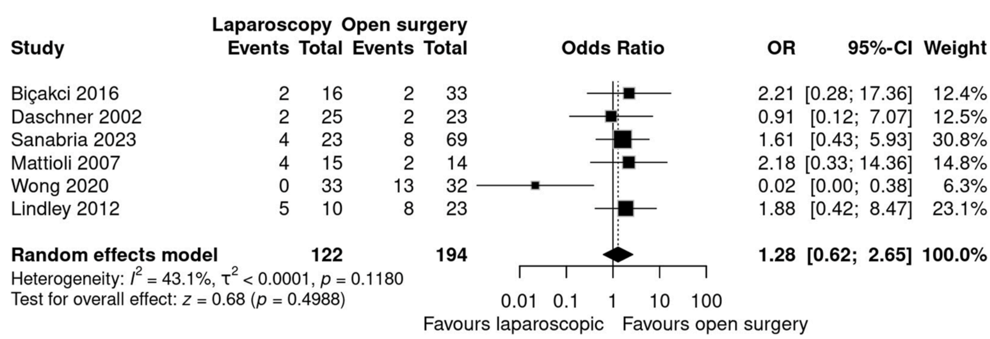

Fig. 6. Forest plot of catheter obstruction rates between the laparoscopic and open surgery groups. It indicates no statistically significant difference between the risk of catheter obstruction in laparoscopic and open surgery.

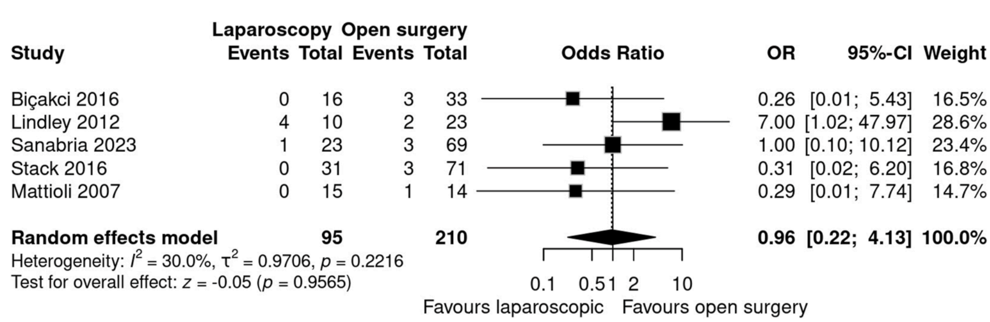

Fig. 7. Forest plot of exit-site infection and tunnel infection rates between the laparoscopic and open surgery groups. It indicates no statistically significant difference between the risk of catheter infection in laparoscopic and open surgery.

3.11. Sensitivity analysis

Leave-one-out sensitivity analyses were performed for all outcomes to evaluate the robustness of the pooled effect estimates. For reoperation, peritonitis, catheter migration, catheter obstruction, and exit-site infection/tunnel infection, the exclusion of any single study did not materially alter the direction or statistical significance of the results, indicating strong

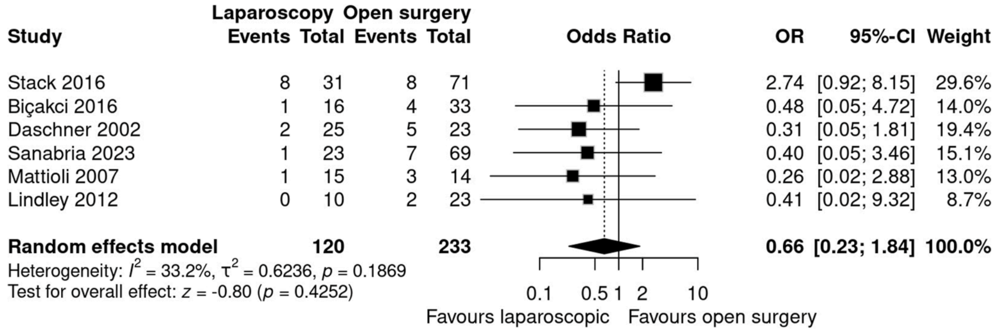

Fig. 8. Forest plot of pericatheter leakage rates between the laparoscopic and open surgery groups. It indicates no statistically significant difference between the risk of pericatheter leakage in laparoscopic and open surgery.

robustness. In contrast, for pericatheter leakage, exclusion of Stack et al. shifted the pooled odds ratio from 0.66 [0.23–1.84]; p = 0.43 to 0.36 [0.13–0.97]; p = 0.042, resulting in statistical significance. This suggests that this outcome may be more sensitive to study-level variation. The leave-one-out sensitivity analyses for the pooled analysis and each individual outcome are presented in Supplementary Fig. S8–S14.

3.12. Power analysis

Post hoc power analysis was conducted for all outcomes using the observed odds ratios, sample sizes, and a two-tailed α level of 0.05. The statistical power was excellent for reoperation (100 %) and peritonitis (99.9 %), indicating strong confidence in the validity of these findings. In contrast, power was lower for catheter obstruction (50.1 %), pericatheter leakage (57.5 %), and catheter migration (28.9 %), suggesting that non-significant results in these outcomes may reflect insufficient sample sizes rather than true absence of effect. These findings underscore the need for larger comparative studies to better evaluate rare mechanical complications. Power was particularly low for exit-site infection/tunnel infection (4.4 %), suggesting that this result should be interpreted with caution.

4. Discussion

This systematic review and meta-analysis evaluated the comparative effectiveness of laparoscopic versus open surgical approaches for peritoneal dialysis (PD) catheter placement in pediatric patients. A total of nine observational studies comprising 659 children were included, allowing for an extensive assessment of postoperative outcomes, with a particular focus on key complications such as peritonitis, catheter migration, obstruction, reoperation, exit-site infection/tunnel infection, and pericatheter leakage. The pooled analysis revealed a statistically significant reduction in overall postoperative complications associated with the laparoscopic approach (OR = 0.55; 95 % CI: 0.33–0.90; p = 0.0175). Among the individual outcomes, reoperation and peritonitis demonstrated the most pronounced benefits in favor of the laparoscopic technique. Specifically, the odds of requiring reoperation were reduced by more than 70 % (OR = 0.28; 95 % CI: 0.08–0.97, p = 0.0444), suggesting enhanced catheter stability and long-term functional integrity with the laparoscopic approach. Additionally, the odds of developing peritonitis were nearly 80 % lower in the laparoscopic group (OR = 0.21; 95 % CI: 0.09–0.52, p = 0.0006), with no observed heterogeneity ($I^2 = 0$ %), underscoring the consistency and potential clinical significance of this finding across the included studies.

The laparoscopic approach offers several intrinsic advantages, including smaller incisions, reduced postoperative pain, shorter hospital stays, and faster recovery, that may contribute to the lower incidence of infectious complications and subsequent peritonitis [14–16]. In addition, laparoscopic techniques enable direct visualization of the peritoneal cavity, allowing for precise catheter placement, optimal tip positioning, and secure fixation. These features are associated with a lower incidence of catheter-related complications, including malposition and migration. A key benefit of laparoscopy is the ability to identify and perform meticulous

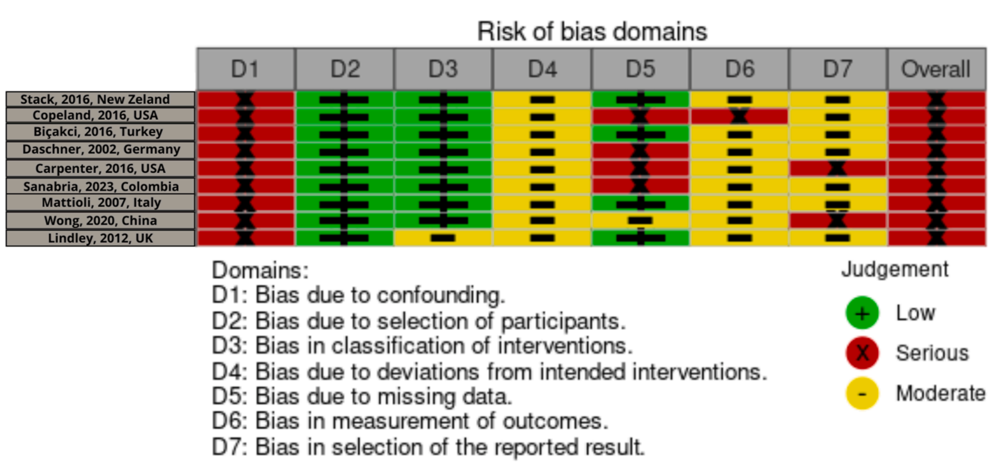

Fig. 9. Quality assessment of included studies.

adhesiolysis, which is particularly relevant in patients with a history of abdominal surgery or intra-abdominal inflammation [17]. By reducing the burden of adhesions, the laparoscopic approach minimizes the risk of catheter dysfunction and the need for revision procedures [18]. Consistently, studies have demonstrated significantly reduced reoperation rates following laparoscopic catheter placement compared to open techniques, likely due to enhanced intraoperative control and improved catheter management [19]. The reduction in postoperative complications, most notably reoperation and peritonitis, observed in our meta-analysis further supports the clinical utility of this approach, with implications for improved catheter longevity, reduced healthcare resource utilization, and better overall quality of life for patients [20,21]. Laparoscopy is increasingly adopted not only as a first-line technique for catheter insertion, but also as the preferred method for salvage procedures in cases of malfunctioning catheters, particularly in patients with prior abdominal surgery who may otherwise be considered poor candidates for peritoneal dialysis [22]. Finally, the favorable cosmetic outcomes associated with minimally invasive surgery may enhance patient satisfaction and improve long-term adherence to peritoneal dialysis, especially in pediatric and adolescent populations.

These findings are consistent with previous literature suggesting a clinical advantage of the laparoscopic approach in pediatric patients requiring peritoneal dialysis. Bıçakcı et al. reported a significantly lower rate of peritonitis in the laparoscopic group ($n = 4$ vs. $n = 25$; $p < 0.01$), with no differences in catheter survival or dialysis adequacy [6]. Similarly, Carpenter et al. observed a 20 % absolute reduction in late complications (57 % in the open group vs. 37 % in the laparoscopic group), with laparoscopy remaining an independent protective factor after adjustment for age and weight [7]. Notably, studies like Copeland et al. and Daschner et al. report that precise pelvic positioning and real-time visualization during laparoscopy contribute to fewer functional failures and longer time to migration [8,9]. Laparoscopy, by providing enhanced intra-abdominal visualization and precise pelvic catheter positioning, has been associated with reduced functional failure rates and improved long-term catheter survival [10,14]. One of the key advantages of the laparoscopic approach lies in the ability to perform adjunct procedures during the same intervention. Several studies, including those by Wong et al. and Mattioli et al., have highlighted the benefits of incorporating omentectomy and closure of a patent processus vaginalis (PPV) at the time of initial catheter placement [10,11]. Wong et al. demonstrated a significantly lower reoperation rate and reduced catheter malfunction using a standardized “3-in-1” laparoscopic technique that combines catheter placement, omentectomy, and PPV closure [11]. This comprehensive approach facilitates a thorough evaluation of the peritoneal cavity, allows for the identification and management of intra-abdominal pathology, and ensures optimal catheter placement, all of which contribute to improved clinical outcomes [10].

Although prior studies have suggested broader benefits of laparoscopy in reducing infectious complications and enhancing long-term catheter function, our meta-analysis identified statistically significant superiority specifically in the reduction of overall postoperative complications, reoperations, and peritonitis, with consistent findings across studies. Conversely, no significant differences were found for other outcomes such as catheter migration, mechanical obstruction, exit-site infection/tunnel infection, or pericatheter leakage. While potential advantages in these domains cannot be excluded, the current evidence does not confirm a definitive benefit of the laparoscopic approach beyond the outcomes in which statistical superiority was observed. However, it is important to acknowledge that the included studies exhibited significant heterogeneity concerning patient demographics, surgical techniques, and outcome reporting. Such variability may have masked subtle differences in these outcomes, highlighting the need for larger, more homogeneous studies to elucidate the impact of surgical approach on these specific complications. Even though the overall findings support the clinical benefits of laparoscopic placement in reducing reoperations and peritonitis, certain patient-specific risk factors remain clinically significant. Sanabria et al. identified infants under 1 year of age and those weighing less than 10 kg as having an inherently higher risk of complications, such as catheter leaks, incisional hernias, and the need for reoperation, regardless of the surgical technique used [14]. These findings underscore the importance of tailoring surgical planning to individual patient characteristics. In this vulnerable subgroup, factors such as abdominal wall thickness, limited peritoneal space, and catheter size may influence both the technical feasibility and postoperative outcomes, and should therefore be carefully considered when selecting the operative approach.

As detailed in the Methods section, all included studies were non-randomized observational cohorts, primarily retrospective, and were judged at moderate to serious risk of bias using the ROBINS-I tool. Key sources of bias included confounding, incomplete data reporting, and lack of statistical adjustment for baseline imbalances such as age, weight, or underlying renal pathology. Only a few studies reported statistical corrections. For instance, Carpenter et al. accounted for age and weight in multivariate models, identifying open technique as a risk factor for late complications [7].

Moderate heterogeneity was observed for certain outcomes (such as catheter obstruction, $I^2 = 54.4$ %), but sensitivity analyses, including leave-one-out testing, confirmed the stability of pooled estimates in most outcomes. Only pericatheter leakage showed a shift toward statistical significance with the exclusion of a single study (Stack et al.), suggesting possible sensitivity to study-level variation. While publication bias was not evident on funnel plot or Egger's test, a formal quantitative bias analysis was not performed.

In our initial study protocol, we aimed to explore several subgroup and secondary outcomes to better understand the comparative effectiveness and safety of laparoscopic versus open techniques for Tenckhoff catheter placement in pediatric patients. However, many of these analyses were precluded due to insufficient data availability or reporting in fewer than three studies, limiting statistical validity. Specifically, we were unable to conduct planned subgroup analyses comparing different laparoscopic techniques, such as two-port versus three-port approaches, or either versus open surgery. Similarly, subgroup analyses based on patient age, gender, and weight could not be performed due to inconsistent or absent reporting. A focused subgroup analysis on omentectomy and its impact on catheter obstruction was attempted, but limited by a lack of events in non-omentectomy groups, preventing meaningful comparisons. Regarding secondary outcomes, including operative time, postoperative complications (such as bleeding, visceral injury, or anesthetic events), hospital length of stay, and time to initiation of dialysis, data were either unavailable or reported inconsistently across studies. Other potentially informative parameters, such as technical success rate and cosmetic or recovery profiles, were also poorly documented. These gaps underscore the need for more standardized reporting in future studies to allow for comprehensive and clinically meaningful meta-analyses.

Despite our rigorous methodology, this meta-analysis is limited by the quality and consistency of the available evidence. No randomized trials were included, and operative techniques varied widely, particularly in the use of fixation sutures, omentectomy, and adjunct procedures such as hernia repair. Important technical variables, such as catheter type (coiled versus straight), number of cuffs, and timing of first use, were inconsistently reported, limiting interpretability. The inclusion of both acute and chronic PD settings, as in the series by Stack et al., introduces further heterogeneity in clinical context [12]. Additionally, definitions of outcomes such as peritonitis and catheter-related infections were not uniform, and follow-up duration varied across studies, potentially leading to underreporting of late complications. Furthermore, although peritonitis was consistently reported across studies, the timing of onset was generally not specified. Due to inconsistent reporting, associations between catheter placement technique and late-onset peritonitis remain uncertain. Future studies should stratify peritonitis by timing to clarify this association.

A temporal bias could be hypothesized, assuming a progressive shift from open to laparoscopic techniques, however our review does not support a consistent chronological trend. For example, early studies such as Daschner et al. (2002) and Mattioli et al. (2007) already reported balanced or predominantly laparoscopic cohorts, while more recent studies, including Sanabria et al. (2023) and Carpenter et al. (2016), still involved majority use of open surgery. This variability likely reflects institutional preference, surgeon experience, and the availability of pediatric laparoscopic infrastructure rather than a consistent chronological trend. Thus, observed differences in outcomes are unlikely to be attributable solely to temporal practice variation.

Given the low likelihood of randomized controlled trials in this population, we recommend the establishment of a multicenter registry focused on technical details of catheter configuration, catheter placement, intraoperative adjuncts, and patient-centered outcomes, including quality of life and functional catheter survival. Such a registry could inform best practices, reduce technique variability, and provide valuable cost-effectiveness analysis.

5. Conclusion

In conclusion, this meta-analysis provides the most comprehensive evidence to date comparing the laparoscopic and open surgery approaches for Tenckhoff PD catheter placement in pediatric patients. Laparoscopy was associated with significantly lower risks of reoperation and peritonitis, with consistent findings across studies and robust sensitivity analyses. While some outcomes showed no significant differences, these may reflect limited statistical power rather than true equivalence. Taken together, our results suggest that laparoscopic catheter placement should be considered the preferred initial approach when feasible, particularly in specialized centers with expertise in minimally invasive pediatric surgery. However, given the lack of randomized controlled trials and methodological heterogeneity among included articles, future prospective studies with standardized surgical protocols are warranted to validate these results and guide clinical decision-making.

Available data

The datasets generated and analyzed during the current study, along with the statistical code used for analysis, are available from the corresponding author upon reasonable request.

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This research did not have any source of funding.

Conflicts of interest

None of the authors has any conflict of interest related to this study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpedsurg.2025.162604.

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