Review Article

Laparoscopic versus Open Surgery Catheter Placement in Peritoneal Dialysis Patients: A Meta-Analysis of Outcomes

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Abstract

Introduction: The peritoneal dialysis catheter (PDC) can be placed either through the laparoscopic technique, percutaneous technique, or surgical procedures. The utilization of these PDC placement procedures is based on the successful placement and reduced risk of development of complications. The main objective of this study was to compare the complications associated with the laparoscopic technique to those linked to open surgery during PDC placement. **Methods:** The literature for this review was obtained from the PubMed and Google Scholar databases. The literature search was limited to studies published in the period between 1998 and 2019. The meta-analysis was done using Stata Version 12. **Results:** The results showed a significant difference in catheter malfunction rates between the laparoscopic and open surgery groups (relative risk [RR] = 0.58; 95% confidence interval [CI]: 0.42–0.8, P = 0.031). There was no statistically significant difference in dialysate leakage (RR = 0.77; 95% CI: 0.51–1.17, P = 0.116), peritonitis (RR = 0.8; 95% CI: 0.6–1.06, P = 0.349), and exit-site infection (RR = 0.84; 95% CI: 0.65–1.09, P = 0.834) between two groups. **Conclusion:** In conclusion, the laparoscopic PDC placement procedure was superior to open surgery with regard to catheter malfunction.

Keywords: *CAPD catheter insertion, laparoscopy-assisted PDC insertion, PDC insertion by open surgery, peritoneal dialysis catheter insertion*

Introduction

Peritoneal dialysis (PD) is one of the accepted alternative treatment methods for end-stage renal disease (ESRD). However, some of the challenges associated with this treatment method include catheter-related infections, leakage of dialysate, and outflow obstruction, among others.[1] Since the introduction of the PD in 1976, increased use of the treatment method has been reported by patients. In the period between 2009 and 2013, for instance, there was a 68% increase in the use of PD among ESRD patients.[2] The increased acceptance of the treatment procedure was attributed to the improved quality of life among patients, the improved catheter survival rates after the first year of dialysis initiation, and good protection of residual renal functioning.[3]

The placement of the peritoneal dialysis catheter (PDC) can be done through an open surgical method, laparoscopic procedure, percutaneous fluoroscopic procedure, or peritoneoscopic implantation.[4] Among the PDC procedures, the open surgical method is commonly used though constrained by high risks of complications among ESRD patients.[5] In recent years, the laparoscopic procedure has been recommended because it is less invasive and has good visibility during catheter placement.[1] Some studies have, therefore, documented the high efficacy of the laparoscopic catheter insertion technique as compared with open surgery.[6] On the other hand, some researchers report that the laparoscopic technique cannot avert the complications of PD.[1,7]

Amid the contradicting information, no studies have extensively and exhaustively compared the open surgery and laparoscopic PDC placement procedures. Furthermore, the most recent meta-analysis studies have not incorporated the current clinical studies.[8] ESRD continues to contribute significantly to the global burden of disease with an annual increasing rate of 20,000 cases.[9,10] This study, thus, aimed at comparing the laparoscopic and open surgery catheter placement procedures with regard to catheter-related complications.

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Materials and Methods

Search strategy

A comprehensive and systematic literature search was conducted in PubMed and Google Scholar for studies focusing on the comparison between laparoscopic and open surgery catheter placement procedures in PD. The following keywords were used in the search: peritoneal dialysis, open surgery, laparoscopic, catheter placement, and ESRD.

Study selection

The inclusion criteria incorporated studies that were randomized controlled trials, cohort studies, or historical studies. It also included studies that measured PDC placement complications, that is, catheter malfunctioning, dialysate leakages, peritonitis, and exit-site infections. Additionally, only the most recent clinical studies were considered (1998–2019). Studies that were excluded were case reports, letters, and studies with unavailable data. Also, practical guides/manuals, non-English studies, and pediatric studies were excluded from the study. Two independent authors reviewed all the articles obtained in the initial search against the inclusion criteria. Disagreements among the reviewers were resolved through consensus.

Data abstraction

Out of the 50 potential studies, 35 were eliminated due to duplication, unavailability of data, focusing on pediatric studies, being noncomparative studies, and having been written in a non-English language [Figure 1]. The data were abstracted using a standard form that captured the number of patients, demographic characteristics, study design, and PDC placement-related outcomes.

Statistical analysis

Statistical analysis was conducted using Stata Version 12 (Stata Corporation, College Station, Texas, USA). Meta-analysis was done to compare the key outcomes of interest (dialysate leakage, catheter malfunction, peritonitis, and exit-site infection) between the open surgery and laparoscopic groups. Forest plots were employed to show the between-study variations in effect sizes. Publication bias was assessed using funnel plots. Additionally, small study effects were investigated using Harbord's regression-based test for small study effects. The heterogeneity across the studies was evaluated using the Q statistic and I^2 index. Statistical analysis was done at the 95% confidence interval.

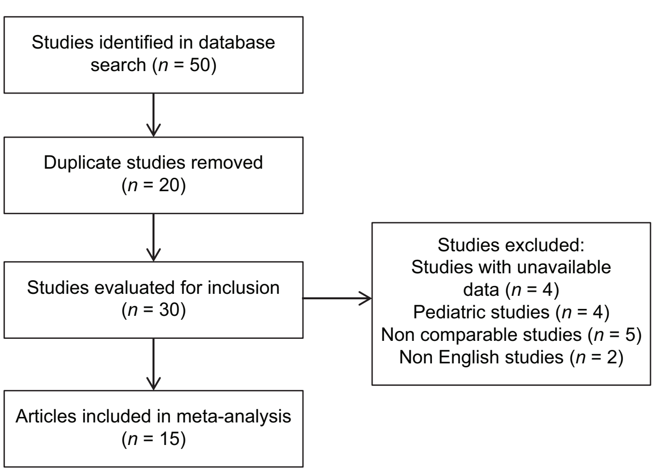

Figure 1: Selection strategy for studies to be included in the meta-analysis

Results

The studies included in the meta-analysis followed 4,819 patients. The patients included in the study were adults aged 51.5 ± 33.5 years. The study period for the incorporated studies was from 1998 to 2019 as shown in Table 1.

Based on the meta-analysis, there was no statistically significant difference in dialysate leakages between the laparoscopic and open surgery groups (relative risk [RR] = 0.77; 95% confidence interval [CI]: 0.51–1.17, P = 0.116) [Figure 2]. There was a significant difference in catheter malfunction between the laparoscopic and open surgery groups (RR = 0.58; 95% CI: 0.42–0.80, P = 0.031) [Figure 3]. Comparison of peritonitis between the laparoscopic and open surgery groups showed that neither of the procedures had inferior incidences of peritonitis (RR = 0.8; 95% CI: 0.6–1.06, P = 0.349) [Figure 4]. There was no significant difference in the exit-site infection between the laparoscopic and open surgery groups (RR = 0.84; 95% CI: 0.65–1.09, P = 0.834) [Figure 5].

Funnel plots of studies included in the meta-analysis reporting on the occurrence of dialysate leakage, catheter malfunction, peritonitis, and exit-site infection between the laparoscopic and open surgery groups are shown in Figures 6-9. All funnel plots were symmetrical leading to the conclusion that there was no publication bias. The risk of bias was assessed using the Harbord test as shown in Tables 2-5. Based on the Harbord regression test, the meta-analysis was not significantly affected by small studies at $P < 0.05$. Therefore, the meta-analysis could be affected by other factors and not small study effects.

Discussion

The success of PD is measured by the reduction of catheter-related complications. Catheter-related complications may result in technical failures that may reduce catheter survival and may consequently warrant hemodialysis.[26]

The results of this meta-analysis show that there was no statistically significant difference in dialysate leakages between the laparoscopic and open surgery PDC placement. The results of this study were similar to other meta-analysis that reported no significant difference in

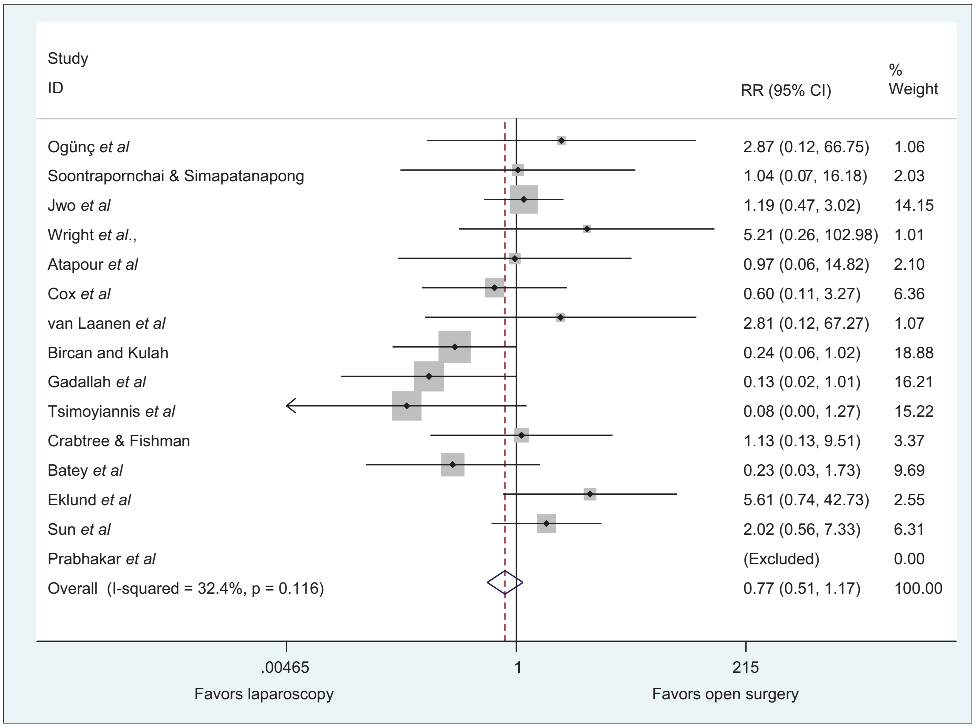

Figure 2: Relative ratio of dialysate leakages between laparoscopic and open-surgery PDC placement technique

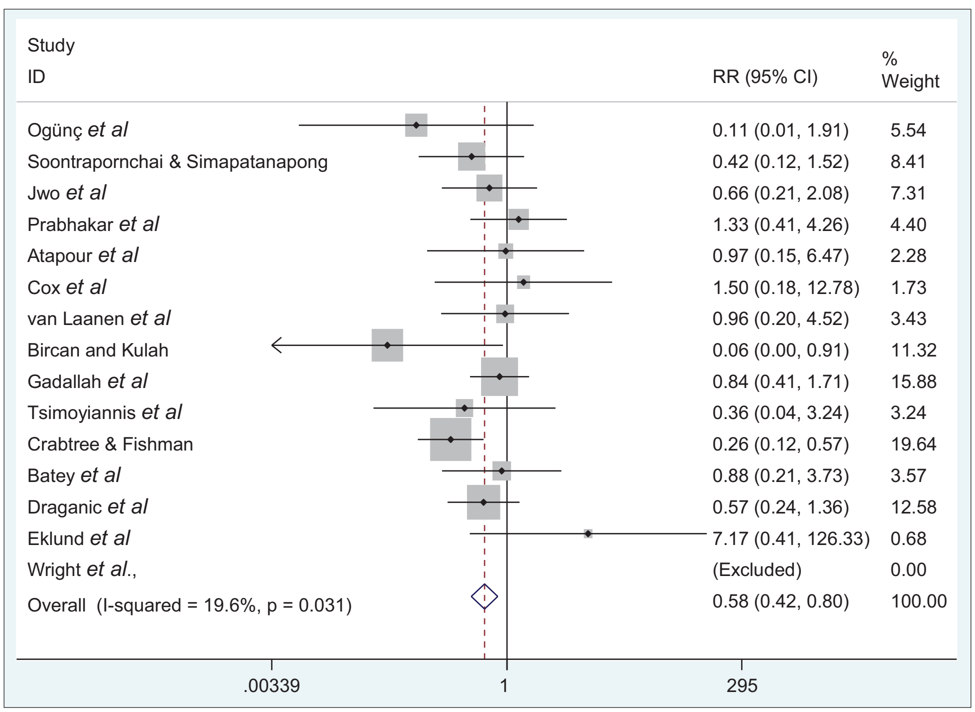

Figure 3: Relative ratio of catheter malfunction between laparoscopic and open surgery PDC placement techniques

dialysate leakages between the laparoscopic and open surgery groups.[27,28] A number of articles have been published that are concurrent with the findings of the meta-analysis. For instance, a prospective randomized study conducted by Jwo *et al.*[1] reported no significant difference in dialysate leakage between the laparoscopic and open surgery groups. Similarly, a review done by Crabtree and Fishman[22] revealed no significant differences in the incidences of dialysate leakage between the open surgery and laparoscopic groups.[22] It is worth noting, however, that dialysate leakage is influenced by other factors such as the time when PD was started. Beginning PD immediately after insertion increases the risk of leakage due to inadequate healing of the peritoneum. Additionally,

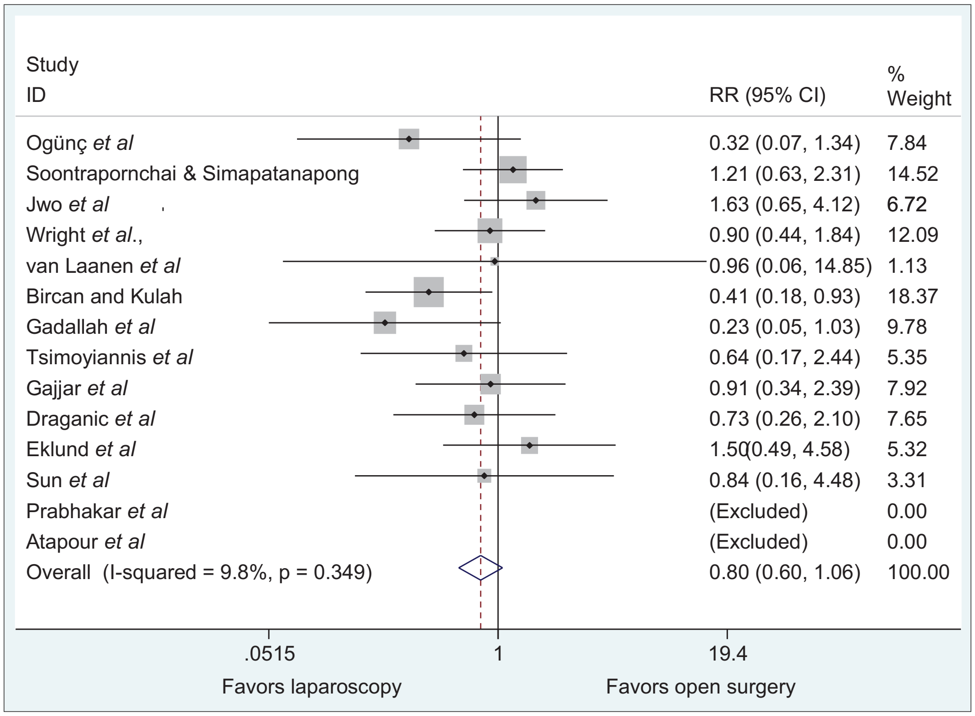

Figure 4: Relative ratio of peritonitis between laparoscopic and open surgery PDC placement techniques

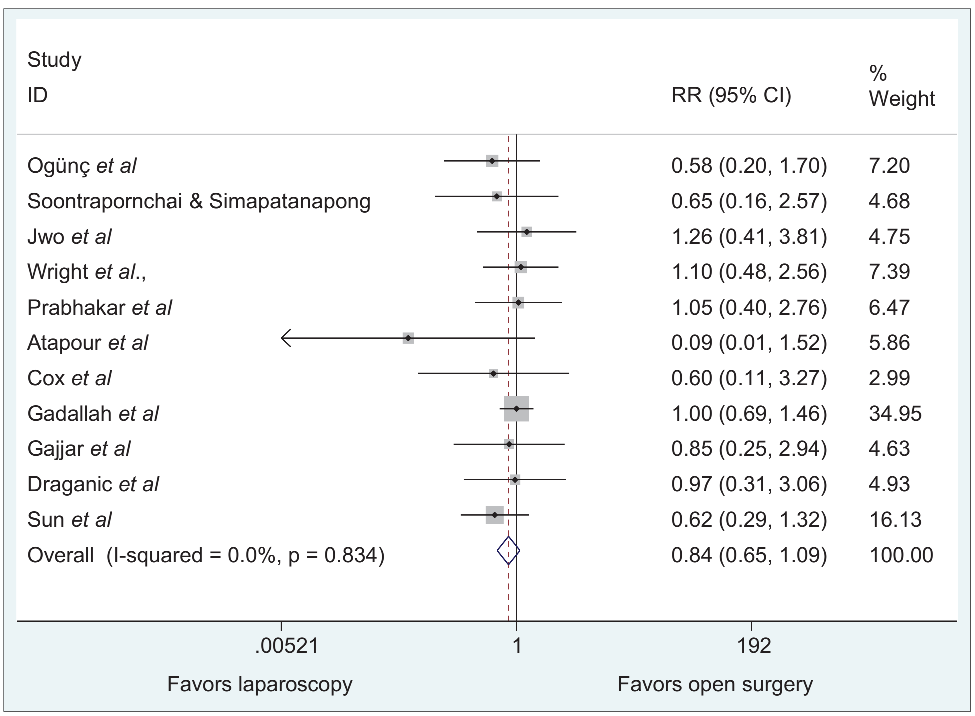

Figure 5: Relative ratio of exit-site infection between laparoscopic and open surgery PDC placement techniques

the number of cuffs in a catheter has been documented to influence the occurrence of leaks, especially for the laparoscopic procedure.[28]

The results of the meta-analysis are in agreement with other meta-analyses that concluded that there was a significant difference in catheter malfunction between the laparoscopic and open surgery groups.[28] Similarly, other studies have reported the laparoscopic procedure as a superior catheter placement procedure with lower incidences of catheter malfunction compared with open surgery. For instance, the study by Crabtree and Fishman,[22] which had the highest weight (19.64%), reported higher incidences (17.5%) in the open surgery group compared with the laparoscopic group (0.5%).[1] However, based on a study conducted in

Table 1: Characteristics of the studies included in the meta-analysis

Study	Country	Year of publication	Study design	Study period	Number of patients	Age (years)	Comparison	Outcomes
Tuncer *et al.*[11]	Turkey	2003	Prospective, nonrandomized	March 1998-October 2001	42	46.9±8.8	Laparoscopic omental fixation vs. open surgical placement	Complications
Soontrapornchai and Simapatanapong[12]	Thailand	2005	Prospective, nonrandomized	May 1999-May 2001	102	57.5±19.1	Open and laparoscopic secure placement	complications
Jwo *et al.*[1]	China	2008	Prospective, randomized	December 2002-October 2006	77	54.4±16.5	Open surgery with laparoscopic assisted placement	Positive findings of complications
Wright *et al.*[13]	UK	1999	Prospective, randomized		45	49.3±20.2	Laparoscopic and open peritoneal dialysis	Complications of catheter insertion
Prabhakar *et al.*[14]	USA	2019	Retrospective, nonrandomized	May 2005-March 2018	173	58.3±1.1	Laparoscopic and open CAPD placement	Complications (infection, malposition, and malfunction)
Atapour *et al.*[15]	Iran	2011	Randomized clinical trial	2009-2010	61	55.1±17.2	Outcome of open surgical procedure and PDC insertion using laparoscopic needle	Complications
Cox *et al.*[16]	USA	2016	Retrospective, nonrandomized	2005-2012	3,134	59.4±24.0	Laparoscopic vs. open peritoneal dialysis	Surgical outcomes for PDC placement
van Laanen *et al.*[17]	Netherlands	2018	Randomized controlled trial	March 2010-March 2016	90	63.6±21.3	Open vs. laparoscopic placement	Reasons for failure and clinical successes
Bircan and Kulah[18]	Turkey	2016	Prospective, nonrandomized	2007-2014	69	63.1±21.1	Open vs. laparoscopic preperitoneal tunneling	Catheter-related complications
Gadallah *et al.*[19]	USA	1999	Prospective, cohort	October 1992-October 1995	148	46.4±4.5	Peritoneoscopic vs. surgical placement	Complications and causes of termination of study monitoring
Tsimoyiannis *et al.*[20]	Greece	2000	Prospective, randomized		50	60±17	Laparoscopic placement of the Tenckhoff catheter	Operative variables
Gajjar *et al.*[21]	USA	2007	Retrospective, nonrandomized		75	55.7±32.2	Laparoscopic vs. traditional placement techniques	Immediate function and complications
Crabtree and Fishman[22]	USA	2005	Prospective, cohort	1992-2002	341	52.3±16.5	Basic and advanced laparoscopic vs. open dissection	Clinical details of PDC placement
Batey *et al.*[6]	Kentucky, USA	2002	Retrospective, cohort	January 2000-March 2001	26	45.5±26.5	Mini laparoscopic-assisted vs. open surgical method	Operative and postoperative data
Draganic *et al.*[23]	Australia	1998	Retrospective, cohort		60	50.5±32.5	Laparoscopy vs. laparotomy	Perioperative complications
Eklund *et al.*[24]	Finland	1998	Retrospective, cohort	June 1994-March 1997	102	51.1±1.1	Peritoneoscopic vs. surgical	Catheter- related complications
Sun *et al.*[25]	New Zealand	2016	Retrospective, cohort	August 2009-July 2013	224	55.2±16.4	Peritoneoscopic vs. surgical	Perioperative outcomes

CAPD=Continuous ambulatory peritoneal dialysis; PDC=peritoneal dialysis catheter

Table 2: Harbord test for small study effects in 14 studies comparing dialysate leakage between laparoscopic and open surgery peritoneal dialysis catheter placement procedure

Z/sqrt (*V*)	Coefficient.	Standard Error	*t*	*P*>*t*	95% Confidence Interval
Sqrt (*V*)	−1.24	0.9392929	−1.32	0.210	−3.289221-0.803866
Bias	1.179963	1.094247	1.08	0.302	−1.204196-3.564121

Test of H0: no small-study effects; *P*=0.302

Table 3: Harbord test for small study effects in 14 studies comparing catheter malfunction between laparoscopic and open surgery peritoneal dialysis catheter placement procedure

Z/sqrt (*V*)	Coefficient	Standard Error	*t*	*P*>*t*	95% Confidence Interval
Sqrt (*V*)	−1.35	0.9195935	−1.47	0.168	−3.354368-0.652876
Bias	1.083912	1.333848	0.81	0.432	−1.822292-3.990117

Test of H0: no small-study effects; *P*=0.432

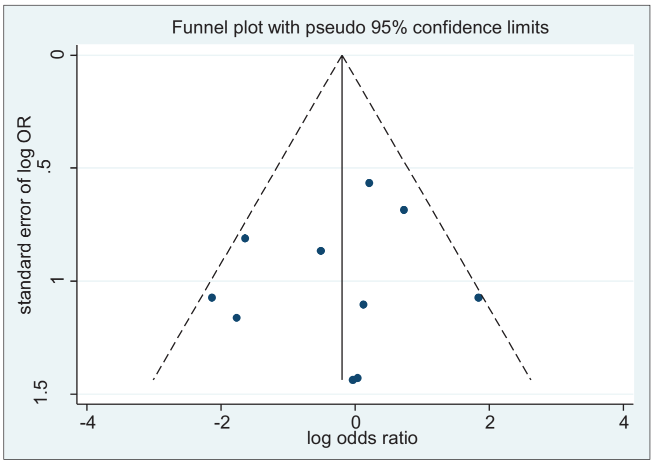

Figure 6: Funnel plot from all studies comparing dialysate leakage between laparoscopic and open surgery PDC placement techniques

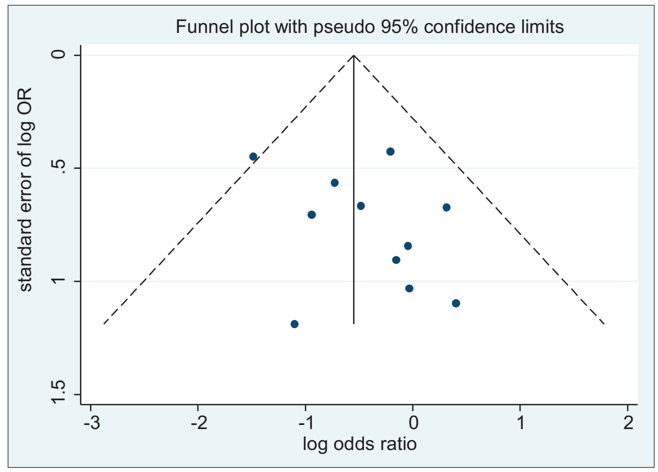

Figure 7: Funnel plot from all studies comparing catheter malfunction between laparoscopic and open surgery PDC placement techniques

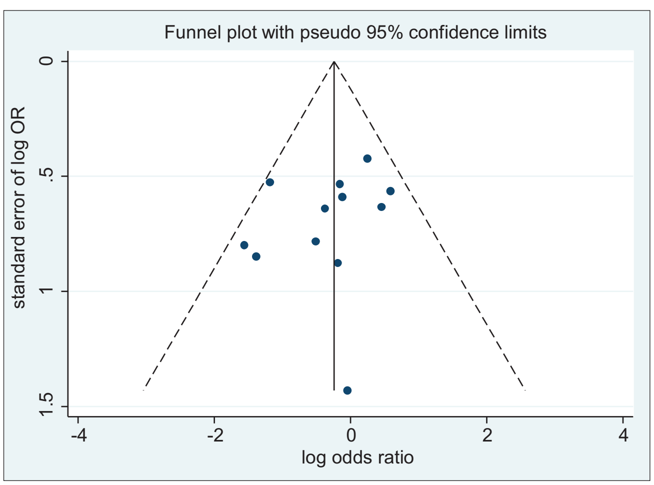

Figure 8: Funnel plot from all studies comparing peritonitis between laparoscopic and open surgery PDC placement techniques

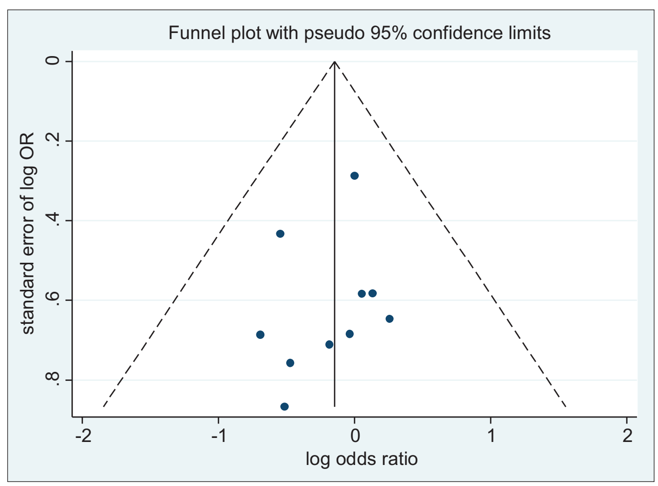

Figure 9: Funnel plot from all studies comparing exit site infection between laparoscopic and open surgery PDC placement techniques

the United States, there was no significant difference in the incidences of catheter malfunction between the laparoscopic and open surgery groups.[19] The inconsistency among the studies could be attributed to the differences in the catheters used in different studies.[28] For instance, studies have reported that the use of coiled catheters tends to reduce incidences of catheter malfunction.[29] Additionally, the size of the studies may confound the results of the meta-analysis.

Peritonitis remains a big impediment to the application of PD and a contributor to patients going back to

Table 4: Harbord test forsmall study effects in 12 studies comparing dialysate leakage between laparoscopic and open surgery peritoneal dialysis catheter placement procedure

Z/sqrt (*V*)	Coefficient	Standard Error	*t*	*P*>*t*	95% Confidence Interval
Sqrt (*V*)	0.05	0.771228	0.07	0.946	−1.665277-1.77153
Bias	−0.5625115	1.290941	−0.44	0.672	−3.438908-2.313885

Test of H0: no small-study effects; *P*=0.672

Table 5: Harbord test for small study effects in 11 studies comparing dialysate leakage between laparoscopic and open surgery peritoneal dialysis catheter placement procedure

Z/sqrt (*V*)	Coefficient	Standard Error	*t*	*P*>t	95% Conf. Interval
Sqrt (*V*)	0.24	0.3787949	0.63	0.543	−0.6175528-1.096234
Bias	−0.9076283	0.6999336	−1.30	0.227	−2.490988-0.6757315

Test of H0: no small-study effects; *P*=0.227

hemodialysis.[30] Based on the results of the meta-analysis, there was no significant difference in peritonitis between the laparoscopic and the open surgery groups ($P = 0.349$). Similarly, another meta-analysis showed that neither the laparoscopic nor the open surgery PDC placement was superior to the other in terms of peritonitis.[27] The results of this study are also consistent with another meta-analysis that recorded no statistically significant difference in peritonitis between the laparoscopic and open surgery groups.[31] It is worth noting that the results of the meta-analysis could be potentially influenced by factors such as the application of perioperative antibiotics, which has been reported to significantly reduce the risk of the early development of peritonitis.[32] Additionally, studies have documented that there is still no consensus on the type of antibiotics to use to prevent the occurrence of peritonitis as well as when the antibiotics should be administered.[28]

Our meta-analysis suggests that there is no significant difference in exit-site infection between the laparoscopic and open surgery PDC placement ($P = 0.834$). Based on a study that had the highest weight (34.95%), the incidence of exit-site infection among the open surgery and laparoscopic groups was not significantly different.[19] Furthermore, the results of this study were in agreement with a previous meta-analysis that reported no statistically significant difference in exit-site infection between the patients subjected to a laparoscopic procedure and an open surgery PDC placement.[8] Additionally, based on a meta-analysis done in 2010, there was no difference in the exit-site infection between the two PDC placement procedures.[31] The potential confounding factor of occurrence of exit-site infection in the open surgery and laparoscopic groups is the time when PD was started after the insertion of a catheter. Some studies recommend the immediate start of PD after catheter insertion,[20] other studies recommend a waiting period of 3 to 5 days,[33] whereas some authors suggest a waiting period of 2 weeks.[12,21,22]

The limitation of the study is that six of the 17 studies included in the meta-analysis were nonrandomized. The nonrandomized studies could have contributed to the bias due to uncaptured differences between the groups. Furthermore, the estimates generated were not adjusted, and hence some confounding factors may have affected negatively on the study. Nevertheless, despite the limitations, the meta-analysis provides meaningful information regarding complications associated with laparoscopic and open surgery PDC placement procedures.

Conclusion

The present study shows that there was a statistically significant difference in catheter malfunction between the laparoscopic and open surgery groups. There were, however, no statistically significant differences in dialysate leakage, peritonitis, and exit-site infection between the laparoscopic and open surgery PDC placement procedures.

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Conflicts of interest

There are no conflicts of interest.

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