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Catheter insertion techniques for improving catheter function and clinical outcomes in peritoneal dialysis patients (Review)

Briggs VR, Jacques RM, Fotheringham J, Maheswaran R, Campbell M, Wilkie ME

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TABLE OF CONTENTS

[Intervention Review]

Catheter insertion techniques for improving catheter function and clinical outcomes in peritoneal dialysis patients

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ABSTRACT

Background

Peritoneal dialysis (PD) relies on the optimal functionality of the flexible plastic PD catheter present within the peritoneal cavity to enable effective treatment. As a result of limited evidence, it is uncertain if the PD catheter's insertion method influences the rate of catheter dysfunction and, thus, the quality of dialysis therapy. Numerous variations of four basic techniques have been adopted in an attempt to improve and maintain PD catheter function. This review evaluates the association between PD catheter insertion technique and associated differences in PD catheter function and post-PD catheter insertion complications

Objectives

Our aims were to 1) evaluate if a specific technique used for PD catheter insertion has lower rates of PD catheter dysfunction (early and late) and technique failure; and 2) examine if any of the available techniques results in a reduction in post-procedure complication rates including postoperative haemorrhage, exit-site infection and peritonitis.

Search methods

We searched the Cochrane Kidney and Transplant Register of Studies up to 24 November 2022 through contact with the Information Specialist using search terms relevant to this review. Studies in the Register are identified through searches of CENTRAL, MEDLINE, and EMBASE, conference proceedings, the International Clinical Trials Register (ICTRP) Search Portal and ClinicalTrials.gov.

Selection criteria

We included randomised controlled trials (RCTs) examining adults and children undergoing PD catheter insertion. The studies examined any two PD catheter insertion techniques, including laparoscopic, open-surgical, percutaneous and peritoneoscopic insertion. Primary outcomes of interest were PD catheter function and technique survival.

Data collection and analysis

Two authors independently performed data extraction and assessed the risk of bias for all included studies. Main outcomes in the Summary of Findings tables include primary outcomes - early PD catheter function, long-term PD catheter function, technique failure and postoperative complications. A random effects model was used to perform meta-analyses; risk ratios (RRs) were calculated for dichotomous outcomes, and mean differences (MD) were calculated for continuous outcomes, using 95% confidence intervals (CIs) for effect estimates. The certainty of the evidence was evaluated using the GRADE (Grades of Recommendation, Assessment, Development and Evaluation) approach.

Main results

Seventeen studies were included in this review. Nine studies were suitable for inclusion in quantitative meta-analysis (670 randomised participants). Five studies compared laparoscopic with open PD catheter insertion, and four studies compared a 'medical' insertion technique with open surgical PD catheter insertion: percutaneous (2) and peritoneoscopic (2).

Random sequence generation was judged to be at low risk of bias in eight studies. Allocation concealment was reported poorly, with only five studies judged to be at low risk of selection bias. Performance bias was judged to be high risk in 10 studies. Attrition bias and reporting bias were judged to be low in 14 and 12 studies, respectively.

Six studies compared laparoscopic PD catheter insertion with open surgical insertion. Five studies could be meta-analysed (394 participants). For our primary outcomes, data were either not reported in a format that could be meta-analysed (early PD catheter function, long-term catheter function) or not reported at all (technique failure). One death was reported in the laparoscopic group and none in the open surgical group. In low certainty evidence, laparoscopic PD catheter insertion may make little or no difference to the risk of peritonitis (4 studies, 288 participants: RR 0.97, 95% CI 0.63 to 1.48; I^2 = 7%), PD catheter removal (4 studies, 257 participants: RR 1.15, 95% CI 0.80 to 1.64; I^2 = 0%), and dialysate leakage (4 studies, 330 participants: RR 1.40, 95% CI 0.49 to 4.02; I^2 = 0%), but may reduce the risk of haemorrhage (2 studies, 167 participants: RR 1.68, 95% CI 0.28 to 10.31; I^2 = 33%) and catheter tip migration (4 studies, 333 participants: RR 0.43, 95% CI 0.20 to 0.92; I^2 = 12%).

Four studies compared a medical insertion technique with open surgical insertion (276 participants). Technique failure was not reported, and no deaths were reported (2 studies, 64 participants). In low certainty evidence, medical insertion may make little or no difference to early PD catheter function (3 studies, 212 participants: RR 0.73, 95% CI 0.29 to 1.83; I^2 = 0%), while one study reported long-term PD function may improve with peritoneoscopic insertion (116 participants: RR 0.59, 95% CI 0.38 to 0.92). Peritoneoscopic catheter insertion may reduce the episodes of early peritonitis (2 studies, 177 participants: RR 0.21, 95% CI 0.06 to 0.71; I^2 = 0%) and dialysate leakage (2 studies, 177 participants: RR 0.13, 95% CI 0.02 to 0.71; I^2 = 0%). Medical insertion had uncertain effects on catheter tip migration (2 studies, 90 participants: RR 0.74, 95% CI 0.15 to 3.73; I^2 = 0%).

Most of the studies examined were small and of poor quality, increasing the risk of imprecision. There was also a significant risk of bias therefore cautious interpretation of results is advised.

Authors' conclusions

The available studies show that the evidence needed to guide clinicians in developing their PD catheter insertion service is lacking. No PD catheter insertion technique had lower rates of PD catheter dysfunction. High-quality, evidence-based data are urgently required, utilising multi-centre RCTs or large cohort studies, in order to provide definitive guidance relating to PD catheter insertion modality.

PLAIN LANGUAGE SUMMARY

Catheter insertion techniques for improving catheter function and clinical outcomes in peritoneal dialysis patients

What is the issue?

Peritoneal dialysis (PD) relies on the insertion of a flexible plastic catheter, which is passed into the peritoneal cavity (space around the abdominal organs) to provide dialysis treatment. This tube must be able to allow the circulation of sterile fluid in and out of the peritoneal cavity several times each day (or overnight) to provide optimum clearance of waste products and water. The technique used to initially place the PD catheter into the peritoneal cavity varies from centre to centre according to local preference and expertise, and hence it is not clear which catheter insertion technique provides the best clinical outcomes for the patient in terms of catheter function, longevity whilst minimising postoperative complications.

What did we do?

We searched the Cochrane Kidney and Transplant Specialised Register up to November 2022. Only 17 of the identified studies could be used in this review. A total of 658 participants were included in the analyses from 9 of the included studies. The other eight studies were only suitable for a descriptive review.

What did we find?

We found that the studies looking at the PD catheter insertion technique were generally of poor quality, and none examined the long-term outcomes of the PD catheter in a way which could be analysed. This means that it is still not known which PD catheter insertion technique is the best for patients in terms of the survival of the catheter. Some studies comparing different PD catheter insertion techniques also looked at complications postoperatively. The peritoneoscopic method of insertion resulted in slightly fewer fluid leaks after surgery. Catheters inserted via this technique can be visualised within the abdominal cavity, but no manipulation of the catheter or extra surgical procedure can take place. There was also a suggestion that the PD catheter moved less frequently from its best position in catheters inserted with a laparoscopic technique when compared to open surgical PD catheter insertion.

Conclusions

We did not find evidence to show that there was a benefit of one PD catheter insertion technique over another. The studies were all small and of poor quality.

Summary of findings 1. Laparoscopic versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in peritoneal dialysis patients

Laparoscopic versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in peritoneal dialysis patients

Patient or population: patients requiring PD catheter placement
Setting: in-centre/outpatient
Intervention: laparoscopic
Comparison: open surgical PD catheter insertion

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (RCTs)	Certainty of the evidence (GRADE)	Comments
	Risk with open surgical PD catheter insertion	Risk with laparoscopic PD catheter insertion				
Early PD catheter function Time frame: within 4 weeks of PD catheter insertion	See comment	See comment	--	383 (5)	--	Definition of early PD catheter function was variable between the studies examined - direct comparison was therefore not possible. Early PD catheter data was not presented in a form which allowed accurate data extraction
Long-term PD catheter function Time frame: > 4 weeks after PD catheter insertion)	See comment	See comment	--	383 (5)	--	Long-term PD catheter function is defined as PD catheter function at 1 year or 2 years. Studies reported outcomes at variable time points and in a format where data could not be accurately extracted (Kaplan-Meier curves - raw data not obtainable)
Technique failure	Not reported	Not reported	--	--	--	--
Postoperative death (relating to PD catheter insertion)	No events	1/84**	RR 0.32 (0.01 to 7.63)	167 (2)	⊕⊖⊖⊖ VERY LOW [1]	--
Peritonitis	241 per 1,000	234 per 1,000 (152 to 357)	RR 0.97 (0.63 to 1.48)	288 (4)	⊕⊕⊖⊖ LOW [2]	--

Time frame: within 4 weeks of PD catheter insertion						
Dialysate leakage (excluding Tsimoyiannis 2000)	30 per 1,000	42 per 1,000 (15 to 121)	RR 1.40 (0.49 to 4.02)	330 (4)	⊕⊕⊖⊖ LOW [3]	Due to high heterogeneity (42%), Tsimoyiannis 2000 was excluded. There was a significant variation in the type of laparoscopic procedure performed in this study. Upon exclusion, heterogeneity was reduced to 0%. No significant difference was demonstrated
Catheter tip migration (mechanical failure)	176 per 1,000	76 per 1,000 (35 to 162)	RR 0.43 (0.20 to 0.92)	333 (4)	⊕⊕⊖⊖ LOW [4]	--

*__The risk in the intervention group__ (and its 95% CI) is based on the assumed risk in the comparison group and the __relative effect__ of the intervention (and its 95% CI).

** Event rate derived from the raw data. A 'per thousand' rate is non-informative in view of the scarcity of evidence and zero events in the intervention group

PD: Peritoneal dialysis; **CI:** Confidence interval; **RR:** Risk ratio

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[1] Downgraded 3 levels: imprecision (3/5 studies did not explicitly report the outcome and only 1 event reported); risk of bias (performance bias)
[2] Downgraded 2 levels: serious risk of bias (study blinding variable or not described); high imprecision (small sample size and wide 95% CIs)
[3] Downgraded 2 levels: high heterogeneity; differing laparoscopic procedures
[4] Downgraded 2 levels: risk of bias (study blinding variable or not described); wide 95% CI and variability between centres

Summary of findings 2. Medical versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients

Medical versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients

Patient or population: improving catheter function and clinical outcomes in PD patients
Setting: in-centre/outpatient
Intervention: medical PD catheter insertion
Comparison: open surgical

Outcomes	Anticipated absolute effects* (95% CI)	Relative effect (95% CI)	No. of participants (RCTs)	Certainty of the evidence (GRADE)	Comments

	Risk with open surgical PD catheter insertion	Risk with medical PD catheter insertion				
Early PD catheter function (within 4 weeks of PD catheter insertion)	95 per 1,000	70 per 1,000 (28 to 174)	RR 0.73 (0.29 to 1.83)	212 (3)	⊕⊕⊖⊖ LOW [1]	--
Late PD catheter failure (> 4 weeks following PD catheter insertion)	552 per 1,000	326 per 1,000 (210 to 508)	RR 0.59 (0.38 to 0.92)	116 (1)	⊕⊖⊖⊖ VERY LOW [2]	--
Technique failure	Not reported	Not reported	--	--	--	--
Postoperative death	No events	No events	--	64 (2)	⊕⊖⊖⊖ VERY LOW [3]	--
Peritonitis	104 per 1,000	22 per 1,000 (6 to 74)	RR 0.21 (0.06 to 0.71)	273 (4)	⊕⊕⊖⊖ LOW [4]	--
Dialysate leakage	89 per 1,000	20 per 1,000 (4 to 84)	RR 0.23 (0.05 to 0.95)	273 (4 studies)	⊕⊕⊖⊖ LOW [4]	--
Catheter tip migration (mechanical failure)	67 per 1,000	49 per 1,000 (10 to 249)	RR 0.74 (0.15 to 3.73)	90 (2 studies)	⊕⊖⊖⊖ VERY LOW [3]	--

*__The risk in the intervention group__ (and its 95% CI) is based on the assumed risk in the comparison group and the __relative effect__ of the intervention (and its 95% CI).

PD: peritoneal dialysis; **CI:** Confidence interval; **RR:** Risk ratio

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[1] Downgraded 2 levels: definition of early function varied between studies (2 to 8 weeks); risk of bias (detection, performance and selection bias)
[2] Downgraded 3 levels: serious risk of bias (study blinding variable or not described, small sample size/wide CI, centre variation); imprecision (only 1 study reported this outcome)
[3] Downgraded 3 levels: imprecision (no events reported; small studies); risk of bias (performance bias)

[4] Downgraded 2 levels: serious risk of bias (study blinding variable or not described); imprecision (small sample size/wide CI, centre variation)

Summary of findings 3. Percutaneous versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients

Percutaneous versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients

Patient or population: improving catheter function and clinical outcomes in PD patients
Setting: in-centre/outpatient
Intervention: percutaneous PD catheter insertion
Comparison: open surgical PD catheter insertion

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (RCTs)	Certainty of the evidence (GRADE)	Comments
	Risk with open surgical PD catheter insertion	Risk with percutaneous PD catheter insertion				
Early PD catheter function (within 4 weeks of PD catheter insertion)	167 per 1,000	58 per 1,000 (7 to 512)	RR 0.35 (0.04 to 3.07)	35 (1)	⊕⊕⊖⊖ VERY LOW [1]	--
Long-term PD catheter failure (> 4 weeks following PD catheter insertion)	Not reported	Not reported	--	--	--	--
Technique failure	Not reported	Not reported	--	--	--	--
Postoperative death	No events	No events	--	35 (1)	⊕⊖⊖⊖ VERY LOW[2]	--
Peritonitis	No events	No events	--	96 (2)	⊕⊖⊖⊖ VERY LOW[2]	--
Dialysate leakage	21 per 1,000	20 per 1,000 (1 to 308)	RR 0.97 (0.06 to 14.78)	96 (2)	⊕⊖⊖⊖ VERY LOW[2]	--
Mechanical failure	146 per 1,000	42 per 1,000 (9 to 194)	RR 0.29 (0.06 to 1.33)	96 (2)	⊕⊖⊖⊖ VERY LOW[2]	--

*__The risk in the intervention group__ (and its 95% CI) is based on the assumed risk in the comparison group and the __relative effect__ of the intervention (and its 95% CI).

PD: Peritoneal dialysis; **CI:** Confidence interval; **RR:** Risk ratio

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[1] Downgraded 3 levels: definition of early function varied between studies (2 to 8 weeks); risk of bias (detection, performance and selection bias)
[2] Downgraded 3 levels: imprecision (no events reported; small studies); risk of bias (performance bias)

Summary of findings 4. Peritoneoscopic versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients

Peritoneoscopic versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients

Patient or population: improving catheter function and clinical outcomes in PD patients
Setting: in-centre/outpatient
Intervention: peritoneoscopic PD catheter insertion
Comparison: open surgical PD catheter insertion

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with open surgical PD catheter insertion	Risk with peritoneoscopic PD catheter insertion				
Early PD catheter function (within 4 weeks of PD catheter insertion) Timepoint: 2 weeks	80 per 1,000	68 per 1,000 (25 to 191)	RR 0.85 (0.31 to 2.38)	177 (2)	⊕⊖⊖⊖ VERY LOW [1]	--
Long-term PD catheter function (> 4 weeks following PD catheter insertion)	552 per 1,000	326 per 1,000 (210 to 508)	RR 0.59 (0.38 to 0.92)	116 (1)	⊕⊖⊖⊖ VERY LOW [2]	--
Technique failure	Not reported	Not reported	--	--	--	--
Postoperative death	No events	No events	--	29 (1)	⊕⊖⊖⊖	--

					VERY LOW [2]	
Peritonitis	161 per 1,000	34 per 1,000 (10 to 114)	RR 0.21 (0.06 to 0.71)	177 (2)	⊕⊖⊖⊖ VERY LOW [2]	--
Dialysate leakage	126 per 1,000	16 per 1,000 (3 to 90)	RR 0.13 (0.02 to 0.71)	177 (2)	⊕⊖⊖⊖ VERY LOW [2]	--
Catheter tip migration (mechanical failure)	67 per 1,000	24 per 1,000 (1 to 538)	RR 0.36 (0.02 to 8.07)	29 (1)	⊕⊖⊖⊖ VERY LOW [2]	--

*__The risk in the intervention group__ (and its 95% CI) is based on the assumed risk in the comparison group and the __relative effect__ of the intervention (and its 95% CI).

PD: Peritoneal dialysis; **CI:** Confidence interval; **RR:** Risk ratio

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
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[1] Downgraded 3 levels: definition of early function varied between studies (2 to 8 weeks); risk of bias (detection, performance and selection bias)
[2] Downgraded 3 levels: imprecision (no events reported; small studies); risk of bias (performance bias)

BACKGROUND

Description of the condition

Peritoneal dialysis (PD) is a form of kidney replacement therapy (KRT) used to treat end-stage kidney disease (ESKD). The management of ESKD is of increasing clinical relevance, given worldwide trends for ESKD prevalence and incidence. In the United States (US) alone, the US Renal Data System (USRDS) reports an incidence of 373 per million population, with over 726,000 prevalent patients requiring treatment (USRDS 2016). Similarly, within the United Kingdom (UK), UK Renal Registry (UKRR) data show an increasing incidence of patients requiring KRT, with over 7000 new patients starting dialysis in 2014 (Gilg 2016; MacNeill 2016). PD utilises the peritoneum as a semi-permeable membrane which allows the removal of waste electrolytes and water by the instillation of dialysate into the abdominal (peritoneal) cavity. This process requires the insertion of a flexible plastic tube, the PD catheter, into the peritoneal space. Optimal catheter functionality is necessary for the success of PD as a dialysis modality.

Approximately 11% of the global population on dialysis are treated with PD. Notably, such utilisation varies internationally (ANZDATA 2015; Jain 2012; USRDS 2016) apparent under-utilisation in countries with developed healthcare systems despite equivalence to other therapeutic modalities (such as haemodialysis, HD) in terms of patient outcomes and economic efficiency (Klarenbach 2009). In the US in 2009, of the approximately 400,000 patients requiring dialysis, only 27,000 received PD (USRDS 2016). The reasons for variation are poorly understood and may relate to PD practice variation. Perl 2015 demonstrated that patients were more likely to receive PD if the catheter was inserted by a nephrologist in comparison to surgical catheter insertion. It has also been observed that mechanical PD catheter problems are a key cause of technique failure in the first year of PD therapy (See 2018). Such observations have led to the hypothesis that the pathway and time to PD catheter insertion are critical determinants of the selection of PD as a therapeutic modality (Asif 2005; Castledine 2013). The Peritoneal Dialysis Outcomes and Practice Patterns (PDOPPS) study, an international observational cohort study (Perl 2016), has been established to follow PD patients longitudinally with the aim of defining best practices, including techniques relating to PD catheter insertion.

In the paediatric population, among patients intended for kidney transplantation, PD is the KRT of choice due to better preservation of residual kidney function in comparison to HD, improved ability to attend school on a regular basis and fewer dietary restrictions (Borzych-Duzalka 2017). PD is also preferred due to the avoidance of vascular access. Surprisingly utilisation of paediatric PD in the UK has fallen over the last 14 years from 55% in the period 2000 to 2004 to 44% in 2014 (UKRR Report 2016a). Although this may be explained by a rise in pre-emptive kidney transplantation, variability in data collection in the paediatric ESKD population is a challenge (UKRR Report 2017).

Description of the intervention

The primary objective of PD catheter placement is to obtain access to the peritoneal cavity to allow the effective exchange of dialysate fluid. Several different techniques are used to achieve this. Many centres rely on a single surgical approach (including open surgical and laparoscopic techniques), whereas others use a combination of insertion techniques (Rao 2015). PD catheter insertion techniques commonly in use include fluoroscopic, percutaneous, peritoneoscopic, laparoscopic and open surgical.

Laparoscopic insertion involves abdominal insufflation and small incisions in the abdominal wall through which surgical instruments can be inserted into the abdominal cavity. The PD catheter is advanced into to the pelvic cavity, and the distal end is tunnelled through the abdominal wall to an exit-site incision (NICE 2007). Additional procedures can be performed simultaneously (e.g. omentectomy and hernia repair). Peritoneoscopic insertion also allows direct vision of the pelvic cavity; however, manipulation of the tube position or other procedures cannot be performed. Open surgical catheter insertion is perhaps the most common technique used to place a PD catheter (UKRR Report 2016b; Wallace 2016). A small open incision is made in the abdomen through the skin, subcutaneous tissue and anterior rectus sheath. A further small incision is made to the peritoneal cavity, and the catheter is threaded into the pelvis (NICE 2007). The posterior rectus sheath and the peritoneum are sutured tightly around the catheter, with the other end of the catheter then tunnelled subcutaneously to an exit-site incision in the abdomen. A variant of the open-surgical technique is the 'mini-laparotomy', where the abdominal incision is minimised to allow the use of local rather than a general anaesthetic.

Percutaneous PD catheter insertion requires a small incision to be made in the abdomen followed by blunt dissection of the subcutaneous tissue. A catheter guide is used to direct the catheter into the peritoneal cavity (Seldinger 1953). The external end of the catheter is tunnelled through to an exit-site incision in the abdomen. Fluoroscopy is a variation of the percutaneous technique, with the use of X-rays to guide the placement of the catheter. The 'Moncrieff' approach describes burying the external end of the catheter under the skin until it is required to perform dialysis. The choice of technique is influenced predominantly by the facilities available (e.g. operating theatre access, availability of trained staff), but in centres where more than one catheter insertion technique is in use, the decision to perform a particular technique may be determined by patient factors such as suitability for general anaesthesia or the requirement for other procedures (e.g. hernia repair).

How the intervention might work

Successful PD relies on the adequate function of the PD catheter. A poorly functioning catheter often leads to the abandonment of the modality with high levels of patient and clinician frustration. There is currently no consensus as to the best method of PD catheter insertion. In the 2012 UK National PD Access Audit, catheters inserted percutaneously were twice as likely to fail compared with catheters inserted via a surgical technique (7% versus 14% failure at 3 months) (Briggs 2014).

A systematic review by Xie 2012 compared laparoscopic and open surgical PD catheter insertion and found no significant difference in outcomes. However, Hagen 2013 found that the laparoscopic technique had significantly better outcomes. The difference between these reviews was considered to be related to the detail of the selection criteria for the studies included. The impact of catheter type and insertion technique on peritonitis rates in patients on PD (Strippoli 2004a; Strippoli 2004b) has also been examined – and did not find that the particular

technique was identified to have any impact on peritonitis rates. Importantly, they also identified that the currently available data are significantly flawed. Hagen 2014 examined catheter type in relation to functional outcome, which favoured a straight intraperitoneal segment (influencing PD catheter survival at two years); however, there was little difference in the PD catheter survival at one year.

Several procedural techniques, such as percutaneous and peritoneoscopic PD catheter Insertion, are being increasingly used for PD catheter insertion in a medical rather than a surgical setting, especially in the management of late-presenting patients. Data from the 2014 UKRR (Briggs 2014) reports highlights that in the UK, approximately 40% of late-presenting patients (who had a PD tube inserted) had this done by the percutaneous route. More recently, in 2017, UKRR data suggests that for this group of patients, there has been little change in the percentage of percutaneous PD catheter insertions (Hole 2017). Boujelbane 2015 examined whether catheters placed percutaneously had any benefits over those placed surgically. They found no significant benefit (or detriment) to having a catheter placed percutaneously over a surgical insertion.

Data from the paediatric population is much less well defined; however, the Italian Registry of Paediatric Chronic Peritoneal Dialysis reported that all PD catheters were surgically implanted, and over 80% of patients underwent omentectomy (Rinaldi 2004). In the paediatric population, current guidance recommends partial omentectomy as a standard procedure in infants undergoing PD catheter insertion due to the higher rates of catheter dysfunction (Watson 2001; Zurowska 2013). Although the open surgical method of catheter insertion is recommended, there is limited available evidence. Specific factors to be considered in children include abdominal wall abnormalities, the presence of 'ostomies', and the presence or absence of nappies must also be taken into account, especially in patients under the age of two years.

More recently, Borzych-Duzalka 2017 presented data from the International Paediatric Dialysis Network looking at access revision procedures. Data from 824 incident and 1629 prevalent patients was examined. Catheter survival rates in incident patients were 84%, 80%, 77%, and 73% at 12, 24, 36, and 48 months, respectively. Risk factors for a catheter revision procedure included younger age, presence of 'ostomies', and congenital abnormalities of the kidney/urinary tract, with 83% of revisions taking place in the first year after PD catheter insertion.

Why it is important to do this review

Currently, no consensus exists with regard to the optimum method of PD catheter insertion, and clinical guidelines are therefore lacking in clarity and consistency. The objective of this review was to examine all possible PD catheter insertion techniques, functional outcomes on PD and post-procedural complication rates, thus broadening the scope of earlier reviews with the intention to maximise the uptake of PD for KRT. Published guidelines relating to PD catheter functionality and post-insertion complication thresholds do exist (ISPD (Figueiredo 2010), European Best Practice Guidelines for Peritoneal Dialysis (EBPG 2005), and the Renal Association (Mactier 2011)); however, their validity has not been rigorously evaluated. Current Renal Association guidelines (Mactier 2011; Wilkie 2009) state the use of timely surgical review to facilitate PD access creation; however, there is no recommended insertion technique as evidence for the benefits of the different techniques is lacking. Surgical technique under direct vision is recommended for patients with previous complex abdominal surgery; however, there is no direct evidence to support this approach. European guidance does not recommend a particular method of PD catheter placement, stating that the insertion technique is dependent on centre expertise and highlights the difficulty with generalisation (EBPG 2005).

OBJECTIVES

This review examined the benefits and harms of different PD catheter insertion techniques.

1. The first objective was to establish whether a specific technique used to place catheters in adults and children, who are new to PD, resulted in any significant differences in clinical outcomes. Insertion techniques were further defined as peritoneoscopic, percutaneous, fluoroscopic, laparoscopic, or insertion by open surgery.
2. The second objective was to identify which technique offered optimal clinical outcomes and minimised post-procedure complications, including postoperative haemorrhage, PD catheter dysfunction, exit-site infection, peritonitis and bowel perforation.

METHODS

Criteria for considering studies for this review

Types of studies

All randomised controlled trials (RCTs) and quasi-RCTs (RCTs in which allocation to treatment was obtained by alternation, use of alternate medical records, date of birth or other predictable methods) comparing PD catheter insertion techniques.

Types of participants

Inclusion criteria

We included adults and children with kidney disease who required PD treatment. This included all patients with ESKD and acute kidney injury.

Participants had a PD catheter inserted, including first or subsequent catheters. Late-presenting patients and those requiring emergency placement of a PD catheter were also included.

Exclusion criteria

There were no exclusion criteria based on the type of participants.

Types of interventions

Studies comparing any two different PD catheter insertion techniques were included.

PD catheter insertion techniques can be defined as 'medical' or 'surgical'. Medical techniques for the purpose of this review include blind percutaneous, peritoneoscopic and fluoroscopic catheter insertion. Surgical PD catheter insertion techniques included laparoscopic or open surgical or any variation.

Studies were not excluded based on operator type. Studies comparing two medical or two surgical techniques were also included (e.g. percutaneous versus peritoneoscopic).

Studies comparing any two of the following catheter insertion techniques were included:

1. Percutaneous PD catheter insertion
2. Fluoroscopic PD catheter insertion
3. Peritoneoscopic PD catheter insertion
4. Open surgical PD catheter insertion
5. Laparoscopic PD catheter insertion

Studies comparing other catheter insertion techniques were included: Buried PD catheter insertion (Moncrieff PD catheter) and advanced techniques such as omentectomy and omentopexy.

Types of outcome measures

Primary outcomes

- Early PD catheter function: catheter function at the time of PD catheter insertion (primary catheter function) and up to 30 days following PD catheter insertion. If the observation period commenced from the start of PD, then this was collected. Early catheter failure was indicated by an event which meant the catheter could not be used to perform a PD exchange/effective PD treatment (which may or may not have required transfer to HD). This is measured as a binary outcome (functioning or non-functioning).
- Long-term PD catheter function: this was defined as a functioning PD catheter that was sufficient to permit successful PD/PD exchanges following catheter insertion. PD catheter failure rate at one year was collected if reported. Catheter failure may or may not have resulted in the transfer to HD. This was also measured as a binary outcome (functioning or non-functioning)
- Technique failure (i.e. the inability to perform successful PD resulting in transfer to HD): technique failure was defined as the patient requiring having been off PD and established on HD for a minimum of 30 days, as described by Lan 2016. In that study percentage returning to PD within 12 months was 24% if the duration on HD was 30 days or less but significantly lower when examining patients with a longer duration on HD (e.g. return after 180 days on HD was 3%). Mechanical causes for technique failure were highest in the 30-day duration of the HD cohort, making it a useful definition in this situation for early technique failure with predominantly mechanical aetiology. Thirty-day transfer to HD and 180-day transfer to HD data were to be collected if reported.
- Death: included in technique failure however death censored technique failure was planned to be reported separately as this has been found to be more sensitive to centre practice. Kidney recovery and transplantation were not classified as technique failure.
- Complications of PD catheter insertion were examined as primary outcome measures. These included:
  - Exit-site infection (early as defined within studies)
  - Early peritonitis episode within 30 days of PD catheter insertion
  - Bowel perforation
  - Haemorrhage/haemoperitoneum
  - Catheter tip migration
  - PD catheter drainage pain
  - Exit-site leakage
  - Catheter use: whether the PD catheter was ever used for PD.

Data regarding patient characteristics (age, gender, co-morbidity, primary kidney diagnosis, previous PD catheter surgery, body mass index (BMI), diabetic status) were collected, and information about the technique of PD catheter insertion, including operator and number of operators per centre. Details regarding the study, such as sample size, study design, length of follow-up and funding source, were also collected. Uncertainties identified in the publications during data extraction were clarified with the authors where possible.

Secondary outcomes

- Additional procedures performed at the time of catheter insertion (e.g. omentopexy/hernia repair)
- Whether patients were able to receive their chosen modality (i.e. automated PD (APD) versus continuous ambulatory PD (CAPD))
- Length of hospital stay
- Estimated glomerular filtration rate at the time of PD catheter insertion
- Re-admission to hospital and further intervention/procedures
- Patient-reported outcomes, e.g. patient satisfaction, health-related quality of life measures
- Cost analysis of PD catheter insertion

Search methods for identification of studies

Electronic searches

We searched the Cochrane Kidney and Transplant Register of Studies up to 24 November 2022 through contact with the Information Specialist using search terms relevant to this review. The Register contains studies identified from the following sources.

1. Monthly searches of the Cochrane Central Register of Controlled Trials (CENTRAL)
2. Weekly searches of MEDLINE OVID SP
3. Handsearching of kidney-related journals and the proceedings of major kidney conferences
4. Searching the current year of EMBASE OVID SP (2022)
5. Weekly current awareness alerts for selected kidney and transplant journals
6. Searches of the International Clinical Trials Register (ICTRP) Search Portal and ClinicalTrials.gov.

Studies contained in the Register are identified through searches of CENTRAL, MEDLINE, and EMBASE based on the scope of Cochrane Kidney and Transplant. Details of search strategies, as well as a list of handsearched journals, conference proceedings and current awareness alerts, are available on the Cochrane Kidney and Transplant website under CKT Register of Studies.

See Appendix 1 for search terms used in strategies for this review.

Searching other resources

1. Reference lists of review articles, relevant studies and clinical practice guidelines.

2. Letters seeking information about unpublished or incomplete studies to investigators known to be involved in previous studies.

Data collection and analysis

Selection of studies

The search strategy described was used to obtain titles and abstracts of studies that may have been relevant to the review. The titles and abstracts were screened independently by two authors, and studies not applicable were discarded; however, studies and reviews that might have included relevant data or information on studies were retained initially. Two authors independently assessed retrieved abstracts and, subsequently, the full text of these studies to determine which studies satisfy the inclusion criteria.

Data extraction and management

Data extraction was carried out independently by two authors (VB/MEW) using standard data extraction forms. Where more than one publication of one study existed, reports were grouped together, and the publication with the most complete data was used in the analyses. Where relevant outcomes were published in earlier versions, these data were used.

Assessment of risk of bias in included studies

Two authors independently assessed the following items using the risk of bias assessment tool (Higgins 2021) (see Appendix 2).

- Was there adequate sequence generation (selection bias)?
- Was allocation adequately concealed (selection bias)?
- Was knowledge of the allocated interventions adequately prevented during the study?
  - Participants and personnel (performance bias)
  - Outcome assessors (detection bias)
- Were incomplete outcome data adequately addressed (attrition bias)?
- Are reports of the study free of suggestion of selective outcome reporting (reporting bias)?
- Was the study apparently free of other problems that could put it at risk of bias?

Measures of treatment effect

For dichotomous outcomes (e.g. peritonitis rate at two weeks, exit-site infection rate, postoperative haemorrhage rate, catheter migration), results were expressed as risk ratio (RR) with 95% confidence intervals (CI). For continuous outcomes (e.g. patient satisfaction measures, length of hospital stay), planned analysis using mean difference (MD).

Skewed data and non-quantitative data were presented descriptively.

Unit of analysis issues

Studies with non-standard designs such as multiple intervention groups were included dependent on study design.

Dealing with missing data

Further information was requested from the original authors by written correspondence (e.g. emailing the corresponding author); however, no responses were obtained. Evaluation of important numerical data such as screened, randomised patients, as well as intention-to-treat, as-treated and per-protocol population, was carefully performed.

Assessment of heterogeneity

Heterogeneity was initially assessed by visual inspection of the forest plot and then quantified statistical heterogeneity using the I^2 statistic, which describes the percentage of total variation across studies that is due to heterogeneity rather than sampling error (Higgins 2003). A guide to the interpretation of I^2 values is as follows.

- 0% to 40%: might not be important
- 30% to 60%: may represent moderate heterogeneity
- 50% to 90%: may represent substantial heterogeneity
- 75% to 100%: considerable heterogeneity.

The importance of the observed value of I^2 depends on the magnitude and direction of treatment effects and the strength of evidence for heterogeneity (e.g. P-value from the Chi^2 test or a CI for I^2) (Higgins 2021).

Assessment of reporting biases

If sufficient RCTs were identified, funnel plots were to be constructed to assess for asymmetry due to small study effect - this may indicate publication bias (Egger 1997).

Data synthesis

Data were pooled using the random-effects model, but the fixed-effect model was also used to ensure the robustness of the model chosen and susceptibility to outliers.

Subgroup analysis and investigation of heterogeneity

Subgroup analysis was used to explore possible sources of heterogeneity (e.g. participants, interventions and study quality). Heterogeneity among participants could relate to age, sex, kidney pathology, diabetic status, BMI or prior surgical intervention. Heterogeneity in the intervention (procedure) could relate to operator type or the number of operators. Adverse effects were tabulated and assessed with descriptive techniques, as they are likely to be different for the various insertion techniques used. Where possible, the risk difference with 95% CI was calculated for each adverse effect, either compared to no treatment or to another procedure type.

Sensitivity analysis

We performed sensitivity analyses in order to explore the influence of the following factors on effect size.

- Repeating the analysis taking account of the risk of bias, as specified
- Repeating the analysis, excluding any very long or large studies to establish how much they dominate the results
- Repeating the analysis excluding studies using the following filter: diagnostic criteria.

Summary of findings and assessment of the certainty of the evidence

The main results of the review are presented in 'Summary of findings' tables. These tables present key information concerning

the quality of the evidence, the magnitude of the effects of the interventions examined, and the sum of the available data for the main outcomes (Schunemann 2021a). The 'Summary of findings' tables also include an overall grading of the evidence related to each of the main outcomes using the GRADE (Grades of Recommendation, Assessment, Development and Evaluation) approach (GRADE 2008; GRADE 2011). The GRADE approach defines the quality of a body of evidence as the extent to which one can be confident that an estimate of effect or association is close to the true quantity of specific interest. The quality of a body of evidence involves consideration of the within-trial risk of bias (methodological quality), directness of evidence, heterogeneity, the precision of effect estimates and risk of publication bias (Schunemann 2021b).

Summary of Findings tables are available for the following outcomes:

- Primary outcome measures: early PD catheter function, late PD catheter function, technique failure, death
- Surgical complications: dialysate leakage
- Infection: peritonitis
- Catheter tip migration

RESULTS

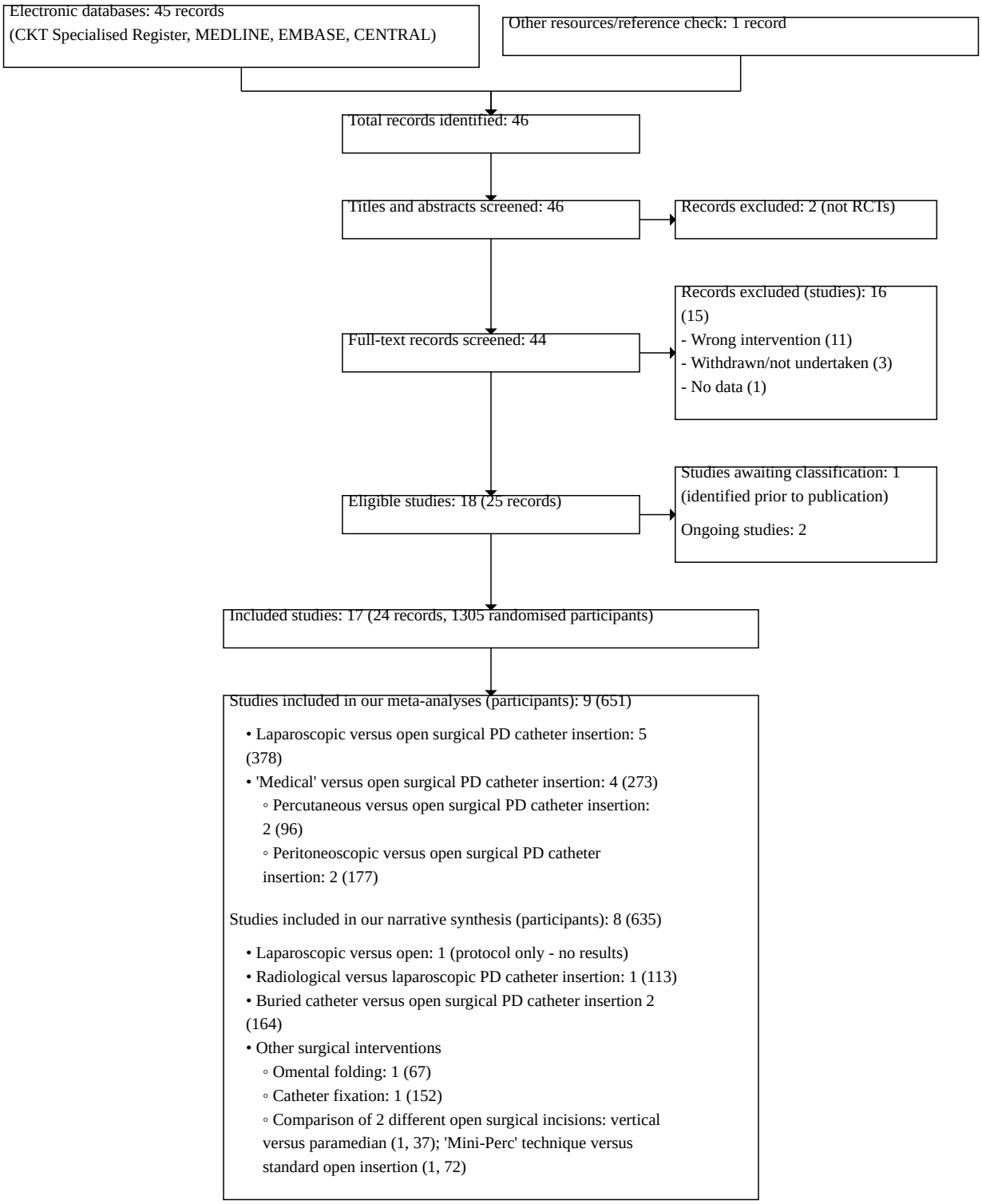
Description of studies

See: Characteristics of included studies; Characteristics of excluded studies; Characteristics of studies awaiting classification; Characteristics of ongoing studies

Results of the search

After searching the Specialised Register, a total of 44 records were identified. After screening titles and abstracts, and full-text review, 17 studies (24 records) were included, and 15 studies (16 records) were excluded. Two ongoing studies were identified (CTRI/2018/02/011871; LOCI 2011), and one study was identified prior to publication (Talwar 2021). These three studies and will be assessed in a future update of this review (Figure 1).

Figure 1. Study flow diagram.



Included studies

Seventeen studies (1305 randomised participants) were identified (Atapour 2011; CAPD I 2018; Chen 2014a; Danielsson 2002; Ejlersen 1990; Gadallah 1999; Jwo 2010; Li 2010c; Merrikhi 2014; Park 1998; Qian 2014; Shahbandari 2019; Tsimoyiannis 2000; Voss 2012; Wright 1999; Zhang 2016; Zhu 2015).

- Six studies compared laparoscopic insertion with open surgical PD catheter insertion (CAPD I 2018; Jwo 2010; Li 2010c; Shahbandari 2019; Tsimoyiannis 2000; Wright 1999)
- Two studies compared percutaneous technique with open surgical PD catheter insertion (Atapour 2011; Merrikhi 2014)
- Two studies compared peritoneoscopic PD catheter insertion with the open surgical technique (Gadallah 1999; Qian 2014)
- One study compared fluoroscopic PD catheter insertion with the laparoscopic technique (Voss 2012)
- Two studies compared buried PD catheters with standard open surgical techniques (Danielsson 2002; Park 1998).
- Two studies compared advanced procedures with standard open PD catheter insertion; omental folding (Chen 2014a) and catheter fixation (Zhang 2016)
- One study compared a 'Mini-Perc' technique (using a ureteroscope, described as a modified open-surgical technique) with open surgical insertion (Zhu 2015)
- One study compared two different open surgical techniques (paramedian versus vertical incision) (Ejlersen 1990).

None of the included studies reported all our outcomes of interest.

Laparoscopic versus open surgical PD catheter insertion

Six studies compared laparoscopic versus open PD catheter insertion (CAPD I 2018; Jwo 2010; Li 2010c; Shahbandari 2019; Tsimoyiannis 2000; Wright 1999). Li 2010c could not be included in the meta-analysis (no available results). A total of 378 participants were included in our meta-analyses. Long-term PD catheter survival was reported by four studies; however, two studies only reported this in graphical form with no available raw data (Tsimoyiannis 2000; Wright 1999). Extraction of this data from the graphical representation was felt to be inaccurate; therefore, a meta-analysis of these two studies was not performed. Other outcomes reported by two or more studies which could be meta-analysed were: outcomes for complications, including dialysate leaks, all-cause PD catheter removal, catheter tip migration, peritonitis, haemorrhage, hernia formation, and exit-site infection.

Percutaneous versus open surgical PD catheter insertion

The two studies (100 participants) examining percutaneous PD catheter insertion reported follow-up for only two months; therefore, long-term PD catheter survival was not available (Atapour 2011; Merrikhi 2014). Merrikhi 2014 was the only paediatric study identified and included patients under the age of 18 years.

Peritoneoscopic versus open surgical PD catheter insertion

Neither Gadallah 1999 nor Qian 2014 reported the primary outcome in a format which could be analysed. Meta-analysis was performed for three outcomes reported by both studies: catheter obstruction (mechanical failure), hernia formation, peritonitis and dialysate leakage (177 participants). Gadallah 1999 reported overall PD catheter failure at the end of the study (three years duration) but excluded patients who had died, chose to stop PD or had a kidney transplant as the cause of PD catheter removal.

Fluoroscopic versus laparoscopic PD catheter insertion

Voss 2012 examined fluoroscopic catheter insertion (113 participants). Narrative results have been presented.

Medical PD catheter insertion versus open surgical PD catheter insertion

Medical PD catheter insertion techniques for the purpose of this review are: percutaneous, fluoroscopic and peritoneoscopic. To compare medical and surgical PD catheter insertion, four studies were included in the meta-analysis (Atapour 2011; Gadallah 1999; Merrikhi 2014; Qian 2014). Outcomes examined were peritonitis, exit-site infection, dialysate leakage and PD catheter tip migration.

Buried versus open surgical PD catheter insertion

Two studies examined buried PD catheter insertion (Danielsson 2002; Park 1998). Park 1998 did not describe the control technique; therefore, it was felt that meta-analysis was inappropriate. The primary outcome for both studies was peritonitis; no data was reported on the secondary outcomes examined, including PD catheter survival.

Other surgical PD catheter interventions

- Ejlersen 1990 compared paramedian with vertical incision (both versions of the open surgical technique)
- Chen 2014a compared those undergoing omental folding as a routine procedure with standard open PD catheter insertion
- Zhang 2016 compared routine PD catheter fixation with standard open PD catheter insertion.

Excluded studies

Fifteen studies were excluded. The reasons for exclusion were:

- Wrong intervention (11 studies): compared site or catheter type rather than insertion techniques (Al-Hwiesh 2016; ChiCTR-TRC-11001848; Eklund 1994; Li 2009e; Misiolek 2012; Nielsen 1995; Rubin 1990; Stegmayr 2015; Sun 2015a; Valdivia-Gomez 2004; Yip 2010)
- Study was terminated (three studies) (ISRCTN87054124; N0547061060; NCT01023191)
- Unable to retrieve article (one study) (Ahmad 2010)

Ongoing studies

Two ongoing studies will be assessed in a future update of this review.

- CTRI/2018/02/011871: laparoscopic PD catheter insertion with or without omentectomy versus open PD catheter insertion
- LOCI 2011: laparoscopic PD catheter insertion with open PD catheter insertion

Studies awaiting classification

Talwar 2021, identified prior to publication, will be assessed in a future update of this review.

- Laparoscopic PD catheter insertion with open PD catheter insertion

Risk of bias in included studies

See Figure 2, Figure 3

Figure 2. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

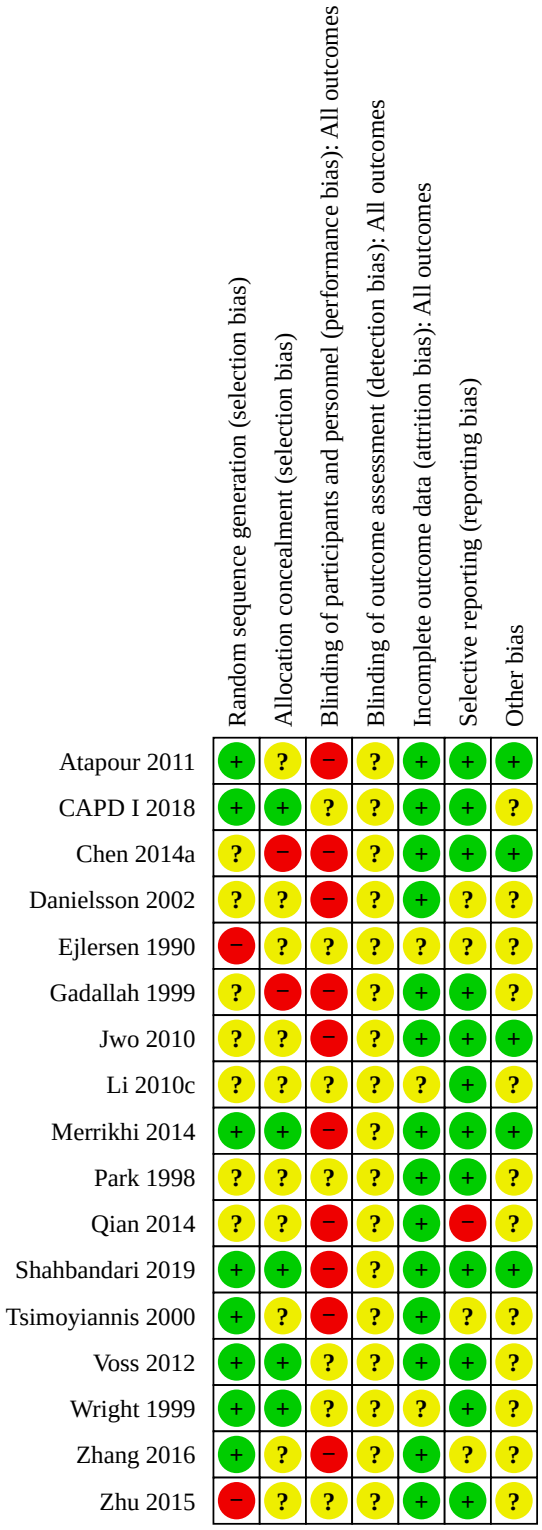
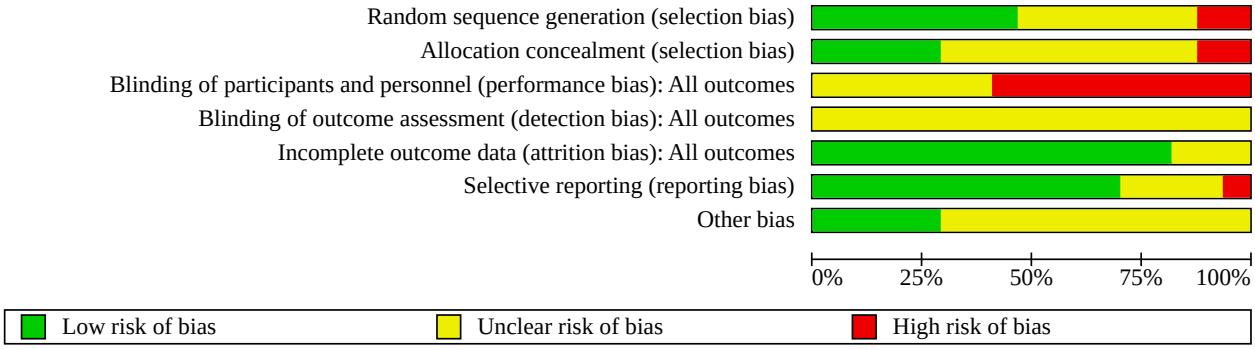


Figure 2. (Continued)

Figure 3. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.



Allocation

Random sequence generation

Random sequence generation was judged to be at low risk of bias in eight studies (Atapour 2011; CAPD I 2018; Merrikhi 2014; Shahbandari 2019; Tsimoyiannis 2000; Voss 2012; Wright 1999; Zhang 2016) and at high risk of bias in two studies (Ejlersen 1990; Zhu 2015). The risk of bias was unclear in the remaining seven studies (Chen 2014a; Danielsson 2002; Gadallah 1999; Jwo 2010; Li 2010c; Park 1998; Qian 2014).

Allocation concealment

Allocation concealment was poorly reported. Allocation concealment was judged to be at low risk of bias in five studies (CAPD I 2018; Merrikhi 2014; Shahbandari 2019; Voss 2012; Wright 1999) and at high risk of bias in two studies (Chen 2014a; Gadallah 1999). The risk of bias was unclear in the remaining 10 studies (Atapour 2011; Chen 2014a; Danielsson 2002; Jwo 2010; Li 2010c; Park 1998; Qian 2014; Tsimoyiannis 2000; Zhang 2016; Zhu 2015).

Blinding

Performance bias

Performance bias (blinding of participants and investigators) was judged to be at high risk of bias in 10 studies (Atapour 2011; Chen 2014a; Danielsson 2002; Gadallah 1999; Jwo 2010; Merrikhi 2014; Qian 2014; Shahbandari 2019; Tsimoyiannis 2000; Zhang 2016) and unclear in seven studies (CAPD I 2018; Ejlersen 1990; Li 2010c; Park 1998; Voss 2012; Wright 1999; Zhu 2015).

Wright 1999 ensured the procedure was concealed from the patient as the cards were only opened once the patient was anaesthetised; however, no other staff were blinded during the procedure.

Detection bias

Blinding of assessors was poorly reported, with the majority of studies not stating whether study investigators were blinded. Detection bias (blinding of outcome assessors) was judged to be unclear in all 17 studies.

Voss 2012 reported that investigators were not involved in patient care; however, given that patients with differing insertion techniques received different types of anaesthetic, the assessing investigators and the patient could discover which technique was used. The data analysts were blinded. Wright 1999 ensured measures were taken so that the patient and the nurses assigned to collect pain scores following the catheter insertion were not aware of which catheter insertion method had been used; however, they did not report how other outcome measures were assessed.

Incomplete outcome data

Attrition bias was judged to be at low risk of bias in 14 studies (Atapour 2011; CAPD I 2018; Chen 2014a; Danielsson 2002; Gadallah 1999; Jwo 2010; Merrikhi 2014; Park 1998; Qian 2014; Shahbandari 2019; Tsimoyiannis 2000; Voss 2012; Zhang 2016; Zhu 2015) and at high risk of bias in three studies (Ejlersen 1990; Li 2010c; Wright 1999).

Selective reporting

Reporting bias was judged to be at low risk of bias in 12 studies (Atapour 2011; CAPD I 2018; Chen 2014a; Gadallah 1999; Jwo 2010; Li 2010c; Merrikhi 2014; Park 1998; Shahbandari 2019; Voss 2012; Wright 1999; Zhu 2015) and at high risk of bias in one study (Qian 2014). The risk of bias was unclear in four studies (Danielsson 2002; Ejlersen 1990; Tsimoyiannis 2000; Zhang 2016).

Other potential sources of bias

Five studies reported funding from University or not-for-profit organisations and were judged to be at low risk of bias (Atapour 2011; Chen 2014a; Jwo 2010; Merrikhi 2014; Shahbandari 2019). The risk of bias was judged to be unclear in the other 12 studies (CAPD I 2018; Danielsson 2002; Ejlersen 1990; Gadallah 1999; Li 2010c; Park 1998; Qian 2014; Tsimoyiannis 2000; Voss 2012; Wright 1999; Zhang 2016; Zhu 2015).

Effects of interventions

See: **Summary of findings 1** Laparoscopic versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in peritoneal dialysis patients; **Summary of findings 2** Medical versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients; **Summary of findings 3** Percutaneous versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients; **Summary of findings 4** Peritoneoscopic versus open surgical PD catheter insertion for improving catheter function and clinical outcomes in PD patients

Laparoscopic versus open surgical PD catheter insertion

Five studies (CAPD I 2018; Jwo 2010; Shahbandari 2019; Tsimoyiannis 2000; Wright 1999) randomised patients to receive either laparoscopic PD catheter insertion or 'standard' PD catheter insertion by the open surgical method. The primary outcome measures (excluding technique failure) were examined by all five studies; however, the available data was presented in a format which could not be meta-analysed. Technique failure was defined as the inability to perform successful PD resulting in transfer to HD; however, it is not clear (in any of the studies examined) whether this was the case. Therefore, no results are presented for this outcome.

Early and late PD catheter function (includes technique failure)

CAPD I 2018 (90 participants) examined early PD catheter function two to four weeks post-insertion; however, the time points are not clearly described. In the open surgical group, 77% of the patients had an adequate functioning PD catheter at two to four weeks compared to 70% of patients in the laparoscopic group (P = 0.48). The term 'adequate' was not defined. At 12 months, PD catheter survival was demonstrated using Kaplan-Meier curves, and results could not be extracted with accuracy; however, the study authors report 60% PD catheter survival in the laparoscopic group and 70% in the open surgical group at 12 months.

Jwo 2010 (77 participants) reported the definition of early PD catheter function as PD catheter failing within four weeks of PD catheter insertion. From the Kaplan-Meier plot provided, it can only be estimated that at four weeks post-PD catheter insertion, PD catheter survival was approximately 90% in both open and laparoscopic groups. Late PD catheter function (defined as PD catheter function at one or two years post insertion) was also only reported using a Kaplan-Meier plot, with no difference in PD catheter survival reported.

Shahbandari 2019 reported early complications at four weeks post-PD catheter insertion. PD catheter obstruction (16.7% laparoscopic, 16.4% open surgical; P = 0.96) and PD catheter movement (11.7% laparoscopic, 24.6% open surgical; P = 0.06) were reported; however, there was no description of early PD catheter survival at four weeks. Long-term PD catheter function was reported (one year PD catheter survival); however, they reported no difference in the PD catheter survival for the two techniques examined. Laparoscopic PD catheter survival was 65%, and open surgical PD catheter insertion was 73.8% (P = 0.09).

Tsimoyiannis 2000 presented very limited data with no clear presentation of the time points at which the outcomes were measured. Early complications were documented as "post-operative". Late PD catheter functional data was limited, with a mean follow-up of 21 months. Only three of the PD catheter inserted were reported to have had mechanical complications by the end of the follow-up period. Some PD catheter placements had an additional procedure performed at the time of insertion (adhesiolysis or PD catheter fixation).

Wright 1999 reported early complications (including PD catheter function) at six weeks post-PD catheter insertion. There were no reported early PD catheter failures due to mechanical complications. Late PD catheter function was reported using a Kaplan-Meier plot, with PD catheter survival estimated at 70% in both groups. The authors were contacted to provide further data; however, these were not available.

Postoperative death

Two studies reported postoperative death (CAPD I 2018; Jwo 2010), and only CAPD I 2018 reported one postoperative death in the open surgical group (Analysis 1.1 (2 studies, 167 participants): RR 0.32, 95% CI 0.01 to 7.63; I^2 = 0%; very low certainty evidence).

Exit-site infection

Three studies reported exit-site infection following PD catheter insertion (CAPD I 2018; Jwo 2010; Wright 1999). Laparoscopic PD catheter insertion may make little or no difference to exit-site infection compared to open surgical PD catheter insertion (Analysis 1.2 (3 studies, 212 participants): RR 1.10, 95% CI 0.59 to 2.06; I^2 = 0%; low certainty evidence).

Peritonitis

Four studies reported early peritonitis rates following PD catheter insertion, describing the total number of peritonitis events (Jwo 2010; Shahbandari 2019; Tsimoyiannis 2000; Wright 1999). Wright 1999 distinguished between early and late peritonitis, defining early peritonitis as less than six weeks postoperatively, and Jwo 2010 divided peritonitis events into early and late; however, the definition of early was less than four weeks from the time of PD catheter insertion. Laparoscopic PD catheter insertion may make little or no difference to the risk of early peritonitis compared to open surgical PD catheter insertion (Analysis 1.3 (4 studies, 288 participants): RR 0.97, 95% CI 0.63 to 1.48; I^2 = 7%; low certainty evidence).

PD catheter removal (any cause)

Four studies reported PD catheter removal (CAPD I 2018; Jwo 2010; Tsimoyiannis 2000; Wright 1999). Laparoscopic PD catheter insertion may make little or no difference to PD catheter removal compared to open surgical PD catheter insertion (Analysis 1.4 (4 studies, 257 participants): RR 1.15, 95% CI 0.80 to 1.64; I^2 = 0%; low certainty evidence).

Postoperative haemorrhage

Two studies reported postoperative haemorrhage (CAPD I 2018; Jwo 2010). It is uncertain whether laparoscopic PD catheter insertion reduces the risk of postoperative haemorrhage because the certainty of the evidence is very low (Analysis 1.5 (2 studies, 167 participants): RR 1.68, 95% CI 0.28 to 10.31; I^2 = 33%).

PD catheter tip migration

Four studies reported PD catheter tip migration (Jwo 2010; Tsimoyiannis 2000; CAPD I 2018; Shahbandari 2019). Laparoscopic

PD catheter insertion may reduce PD catheter tip migration compared to open surgical PD catheter insertion (Analysis 1.6 (4 studies, 333 participants): RR 0.43, 95% CI 0.20 to 0.92; I^2 = 12%; low certainty evidence).

Dialysate leakage

Five studies reported postoperative dialysate leakage (CAPD I 2018; Jwo 2010; Shahbandari 2019; Tsimoyiannis 2000; Wright 1999). Laparoscopic PD catheter insertion may make little or no difference to the risk of postoperative dialysate leakage compared to open surgical PD catheter insertion (Analysis 1.7.1 (5 studies, 378 participants): RR 0.92, 95% CI 0.22 to 3.93; I^2 = 42%, low certainty evidence). A sensitivity analysis excluding Tsimoyiannis 2000 reduced the heterogeneity but made little or no difference to the summary estimate, with 95% CI still crossing the line of no effect (Analysis 1.7.2 (4 studies, 330 participants): RR 1.40, 95% CI 0.49 to 4.02; I^2 = 0%),

Medical versus open surgical PD catheter insertion

Medical insertion techniques include percutaneous PD catheter insertion, peritoneoscopic PD catheter insertion and radiological/fluoroscopic PD catheter insertion. The definitions of these techniques can be found in the Methods section.

Four studies compared a medical insertion technique with open surgical PD catheter insertion. Two studies used percutaneous PD catheter insertion (Atapour 2011; Merrikhi 2014), and two used peritoneoscopic PD catheter insertion (Gadallah 1999; Qian 2014).

Early PD catheter function

Three studies reported early PD catheter function (Gadallah 1999; Merrikhi 2014; Qian 2014). Medical PD catheter insertion may make little or no difference to early PD catheter function compared to open surgical PD catheter insertion (Analysis 2.1 (3 studies, 212 participants): RR 0.73, 95% CI 0.29 to 1.83; I^2 = 0%; low certainty evidence).

Subgroup analyses showed similar results:

- Percutaneous PD catheter insertion (Analysis 2.1.2 (1 study, 35 participants): RR 0.35, 95% CI 0.04 to 3.07)
- Peritoneoscopic PD catheter insertion (Analysis 2.1.2 (2 studies, 177 participants): RR 0.85, 95% CI 0.31 to 2.38; I^2 = 0%)

Long-term PD catheter function

Gadallah 1999 reported one-year PD catheter survival may improve with peritoneoscopic PD catheter insertion compared to the open surgical method (Analysis 2.2 (1 study, 116 participants): RR 0.59, 95% CI 0.38 to 0.92).

Mechanical catheter failure

Two studies reported mechanical catheter failure (Atapour 2011; Merrikhi 2014). Percutaneous PD catheter insertion may make like or no difference to mechanical catheter failure compared to the open surgical method (Analysis 2.3 (2 studies, 96 participants): RR 0.29, 95% CI 0.06 to 1.33; I^2 = 0%; low certainty evidence).

Postoperative death

Both Merrikhi 2014 and Qian 2014 reported no postoperative deaths in either the medical or the open surgical groups.

Exit-site infection

It is uncertain whether medical PD catheter insertion reduces the risk of exit-site infection because the certainty of this evidence is very low (Analysis 2.5 (3 studies, 125 participants): RR 0.21, 95% CI 0.04 to 1.21; I^2 = 0%).

Subgroup analyses showed similar results:

- Percutaneous PD catheter insertion (Analysis 2.5.1 (2 studies, 96 participants): RR 0.17, 95% CI 0.02 to 1.37; I^2 = 0%)
- Peritoneoscopic PD catheter insertion (Analysis 2.5.2 (1 study, 29 participants): RR 0.36, 95% CI 0.02 to 8.07)

Peritonitis

All four studies reported peritonitis. Medical PD catheter insertion may reduce the episodes of early peritonitis Analysis 2.6 (4 studies, 273 participants): RR 0.21, 95% CI 0.06 to 0.71; I^2 = 0%, low certainty evidence).

- Percutaneous PD catheter insertion: both Atapour 2011 and Merrikhi 2014 reported no peritonitis in either the medical or open surgical groups
- Peritoneoscopic PD catheter insertion (Analysis 2.6.2 (2 studies, 177 participants): RR 0.21, 95% CI 0.06 to 0.71; I^2 = 0%)

Haemorrhage

Two studies reported haemorrhage (Atapour 2011; Merrikhi 2014). It is uncertain whether percutaneous PD catheter insertion reduces the risk of haemorrhage because the certainty of the evidence is very low (Analysis 2.7 (2 studies, 96 participants): RR 0.23, 95% CI 0.04 to 1.31; I^2 = 0%).

Haemorrhage was not reported by either of the peritoneoscopic PD catheter insertion studies.

PD catheter tip migration

Two studies reported PD catheter tip migration (Atapour 2011; Qian 2014). It is uncertain whether medical PD catheter insertion reduces the risk of PD catheter tip migration because the certainty of the evidence is very low (Analysis 2.8 (2 studies, 90 participants): RR 0.74, 95% CI 0.15 to 3.73; I^2 = 0%).

Subgroup analyses showed similar results:

- Percutaneous PD catheter insertion (Analysis 2.8.1 (1 study, 61 participants): RR 0.97, 95% CI 0.15 to 6.44)
- Peritoneoscopic PD catheter insertion (Analysis 2.8.2 (1 study, 29 participants): RR 0.36, 95% CI 0.02 to 8.07)

Dialysate leakage

All four studies reported dialysate leakage following PD catheter insertion. Medical PD catheter insertion may reduce dialysate leakage (Analysis 2.9 (4 studies, 273 participants): RR 0.23, 95% CI 0.05 to 0.95; I^2 = 0%; low certainty evidence).

Subgroup analyses showed little or no difference with percutaneous PD catheter insertion (Analysis 2.9.1 (2 studies, 96 participants): RR 0.97, 95% CI 0.06 to 14.78; I^2 = 0%), but a reduction with peritoneoscopic PD catheter insertion (Analysis 2.9.2 (2 studies, 177 participants): RR 0.13, 95% CI 0.02 to 0.71; I^2 = 0%).

Hernia formation

Two studies reported hernia formation, both using peritoneoscopic PD catheter insertion (Gadallah 1999; Qian 2014). It is uncertain whether peritoneoscopic PD catheter insertion reduces hernia formation because the certainty of the evidence is very low (Analysis 2.10 (2 studies, 177 participants): RR 0.47, 95% CI 0.06 to 3.55; I^2 = 0%).

Catheter obstruction

Two studies reported catheter obstruction, both using peritoneoscopic PD catheter insertion (Gadallah 1999; Qian 2014). It is uncertain whether peritoneoscopic PD catheter insertion reduces catheter obstruction because the certainty of the evidence is very low (Analysis 2.11 (2 studies, 177 participants): RR 0.85, 95% CI 0.31 to 2.38; I^2 = 0%).

Omental wrapping

Two studies reported omental wrapping, both using percutaneous PD catheter insertion (Atapour 2011; Merrikhi 2014). It is uncertain whether percutaneous PD catheter insertion reduces omental wrapping because the certainty of the evidence is very low (Analysis 2.12 (2 studies, 96 participants): RR 0.25, 95% CI 0.06 to 1.13; I^2 = 0%).

Radiological versus laparoscopic PD catheter insertion

Voss 2012 compared radiologically guided fluoroscopic PD catheter insertion with laparoscopic PD catheter insertion. The study was a non-inferiority RCT which excluded patients who were obese or who had previous abdominal surgery and initially aimed to examine whether radiological PD catheter insertion was as effective as laparoscopic insertion.

This study also examined the economic impact of each type of PD catheter insertion, particularly as the type of anaesthetic affects the duration of stay for each procedure. Laparoscopy requires a general anaesthetic, whilst radiologically guided can be done with local anaesthesia. The results from this study did not demonstrate a difference in the time within the procedure room or the time to hospital discharge (P = 0.13, P = 0.78, respectively), but there was likely a difference in pain scores, procedure time and the direct hospital costs (P < 0.001, P = 0.029 and P < 0.001).

Results from this study did not show any difference in overall PD catheter survival (Hazard ratio (HR) for radiological insertion 0.63, 95% CI 0.27 to 1.45, P = 0.27); however, patients with a radiologically inserted PD catheter probably had a higher chance of achieving complication-free PD catheter survival (P = 0.03). This was demonstrated through survival analysis and Kaplan-Meier survival curves. PD catheter failure in both groups was either due to PD catheter tip migration or unrecognised adhesions and did not differ between the two groups. Peritonitis was probably more frequent in the laparoscopic group (P = 0.05).

Fluoroscopic PD catheter insertion was not inferior to the laparoscopic technique; however, there was evidence to suggest that the radiological insertion was actually superior in this study. HR for all patients with early PD catheter complications was 0.84 (95% CI 0.42 to 1.68). Given that this was a single study, more evidence is have been needed to validate these findings. The authors acknowledge this and highlight that the reported better outcomes with laparoscopy are often by those using advanced techniques not available in many centres.

Buried PD catheters versus open surgical PD catheter insertion

Two studies were found comparing buried PD catheter insertion versus conventional PD catheter insertion. Park 1998 did not include a description of the control technique within the report. This was reported as a ‘conventional technique’ however, 'conventional’ will depend very much on the centre and could be any one of the PD catheter insertion techniques already described. For this reason, although there are two included studies, we did not perform a meta-analysis.

Danielsson 2002 performed a prospective RCT which included all patients who were not expected to commence PD for at least six weeks. Those patients starting acutely within six weeks were excluded, but their data were collected and presented for comparison. All these patients had a standard open surgical PD catheter insertion. Those patients included in the study were randomised to either a standard open surgical PD catheter insertion or a buried PD catheter placement. PD catheter failure due to mechanical reasons was very low, with only one patient in the buried PD catheter group terminating PD for this reason. No patients in the open surgical group terminated PD for mechanical PD catheter failure.

They report lower peritonitis rates in the buried PD catheter group; however, P values were not reported, and the Kaplan-Meier curves produced were not sufficiently detailed to be able to extract this information.

Limitations of the study included the fact that insertions were performed in different hospitals by different operators – whilst not in itself an issue – the actual technique differed slightly between the two centres and is described in the report. This meant that the validity of the comparisons was unclear. The authors acknowledge this and examined infection rates between the two centres. They did not find any significant differences but do not report these findings.

Park 1998 performed a single-centre RCT comparing prolonged subcutaneous implantation with the standard technique used in that centre. A total of 60 patients were randomised. The PD catheter was exteriorised six weeks after implantation. One patient was excluded from the study as they developed severe ultrafiltration failure shortly after commencing PD. The primary outcome of the study was peritonitis rates. Patients were further randomised to use either a Y-connector or standard spike technique when performing PD exchanges. Peritonitis data were reported; however, complication rates, PD catheter survival and technique survival were not. Patients were followed for two years after the start of treatment or until the cessation of treatment (death or transfer to HD).

Data reported on the four study groups suggest that those patients with a PD catheter inserted via the 'conventional' technique and using a standard spike connection had the poorest outcome, with one episode of infection every 9.3 months. The study did not fully describe the method of PD catheter insertion, and the primary outcome of the study was to examine infection rates rather than PD catheter survival.

Other surgical PD catheter interventions

Whilst not a direct comparison of insertion techniques, Chen 2014a, performed a prospective RCT examining the role of greater omental folding in the optimisation of PD catheter function. The greater omentum comprises connective tissue, mesothelium and fat and has several functions within the peritoneal cavity, including a role in the immune response. Omental wrapping is a cause of PD catheter dysfunction and often leads to PD catheter removal or replacement, as seen in studies already described within this review.

The study included adults requiring PD as their dialysis modality, and patients were randomised to either standard open PD catheter insertion or open PD catheter insertion with omental folding. Patients developing mechanical PD catheter dysfunction during the study who did not respond to conservative measures had a surgical intervention to reposition or remove the PD catheter. Omental wrapping as the cause for PD catheter failure could only be diagnosed at this point.

One difficulty in the study was that patients without the presence of the greater omentum below the abdominal incision were excluded (76 patients, with a further 3 patients excluded due to the procedure being a second PD catheter insertion attempt). The implication was that patients could not be randomised until surgery to insert the PD catheter had begun, and this was at the discretion of the operating surgeon. There was, therefore, a high risk of operator bias within this study. The authors recognised this as a difficulty and stated measures which were used to minimise this bias, such as standardised outcome measures and surgical procedures.

The results demonstrated that there was no difference in technique failure between the two insertion techniques (P = 0.32), infection rates (P = 0.74), or other postoperative complications such as bleeding (P = 0.35) and dialysate leakage (P = 0.57); but there were probably lower levels of PD catheter tip migration in patients with omental folding (P = 0.04) and those with irreversible PD catheter dysfunction (P = 0.03).

Further work is needed to establish the validity of these results and their applicability to other populations. The authors acknowledge that no other RCTs were performed examining this area of PD catheter insertion practice.

A second study examining PD catheter fixation within the pelvis at the time of PD catheter insertion was performed by Zhang 2016. A modified surgical technique with fixation of the PD catheter to the anterior abdominal wall was compared to standard open surgical PD catheter insertion. Complication rates were comparable between the two techniques however PD catheter tip migration (with PD catheter malfunction) was lower in the group with PD catheter fixation (P < 0.05). PD catheter survival at one year following PD catheter insertion was 84% in the traditional open surgical group and 96% in the modified open surgical group. For those patients with PD catheter fixation, the survival at one year was 100%.

Ejlersen 1990 examined two different versions of open PD catheter insertion. A prospective RCT examining patients who had PD catheter insertion via the standard method (vertical incision) versus those who had a paramedian incision. They examined a number of outcomes, including surgical and mechanical failure (PD catheter displacement, dialysate leakage and peri-catheter herniation), infection (tunnel infection and exit-site infection) and other causes for transfer off PD (transplantation, death, recovery of kidney function). The difference in PD catheter function after one year was not felt to be significant (P = 0.4), although the group accept that this study was likely underpowered. The most common reason for PD catheter failure was PD catheter displacement (4/21 in the midline group and 7/16 in the lateral group).

DISCUSSION

Summary of main results

The overall results of our meta-analyses do not suggest a benefit for laparoscopic over open PD catheter insertion for any of the specified postoperative complications, with the possible caveat following sensitivity analysis that PD catheters inserted via the open surgical technique have a lower leakage rate than those inserted laparoscopically.

It was not possible to perform an accurate meta-analysis of PD catheter survival (including the primary outcomes of early PD catheter function, late PD catheter function and technique survival) from the five RCTs available as the data was not presented in a format which allows accurate extraction of this outcome. This is because only CAPD I 2018 provided data in its raw form, with the remaining four studies only providing graphical Kaplan-Meier survival representation. Previous systematic reviews (Hagen 2014; Tullavardhana 2016; Xie 2012) have performed meta-analyses using this data; however, we did not feel that it was possible to do so accurately.

All the studies that we have presented utilise slight variations of the laparoscopic technique, and it is likely that the methodology of insertion will differ slightly amongst operators dependent on their level of training and knowledge. However, all the studies included in this review are RCTs with low heterogeneity. Where heterogeneity is high, sensitivity analysis has been performed to investigate why that might be the case. For example, Tsimoyiannis 2000 uses a methodology that included an additional technique where PD catheters were sutured in the peritoneal cavity during insertion - a procedure which was not carried out in the other included studies. As PD catheter fixation could be considered a deviation from standard open PD catheter insertion, this study was excluded from an additional meta-analysis with a reduction in heterogeneity seen (I^2 = 0%) Tsimoyiannis 2000 found an extremely high rate of PD catheter dialysate leaks in the open PD catheter insertion group not seen in other RCTs included in this review.

Other studies reported some additional techniques - CAPD I 2018 included adhesiolysis where necessary and pre-peritoneal tunnelling for all cases, and Jwo 2010 included adhesiolysis.

The two studies included in the meta-analysis for peritoneoscopic insertion had significant differences in their methodologies – since one of the studies used a cystoscope rather than a standard peritoneoscope; however, the described procedures were similar in other aspects (Gadallah 1999; Qian 2014). The heterogeneity between these RCTs is low; therefore, meta-analysis was considered appropriate.

There was no demonstrable effect in the rate of PD catheter obstruction comparing peritoneoscopic with open insertion. The

number of postoperative dialysate leaks in the peritoneoscopic PD catheter insertion group was lower (RR 0.13, 95% CI 0.02 to 0.71, P = 0.02). There is a concern as Gadallah 1999 reported significantly higher complication rates than observed in other studies examining these techniques; however, as previously stated, heterogeneity between these two RCTs was low.

It should be noted that Gadallah 1999 reported the 12-month PD catheter survival rate in the open surgical group to be well below that which is commonly seen (RR 0.59, 95% CI 0.38 to 0.92) – for example, in the UKRR Report 2017, the average one-year PD catheter survival was approximately 80%. Whilst the PD catheter survival was better than that seen in the open surgical group, this was only the case as the open surgical outcomes are so poor.

We have included two studies in the meta-analysis and have supported this with a narrative review. A key concern with respect to the meta-analysis is that one of the studies included children and the other only adults. Both studies were performed in the same Iranian centre, and follow-up was short (two months) therefore, no inference could be made regarding long-term outcomes for PD catheters placed percutaneously when compared to those placed surgically. Both studies also reported the duration of hospital stay and operative time, and there were no differences in these times between the two studies. It is not clear whether the operators were the same in the two studies. The operative time in the percutaneous insertion group was significantly higher (approximately 10 minutes) than in the open surgical group in both studies (approximately 27 minutes) (P = 0.0001).

There was no demonstrable difference between the two techniques in early PD catheter failure; however, there may be a reduction in rates of early peritonitis and exit-site infections however the certainty of the evidence is very low.

Voss 2012, a single non-inferiority RCT compared radiologically guided fluoroscopic with laparoscopic PD catheter insertion, excluded patients who were obese or who had previous abdominal surgery. This study also examined the economic impact of each type of PD catheter insertion, particularly as the type of anaesthetic can impact the length of hospital stay for each procedure, and laparoscopy requires a general anaesthetic whilst percutaneous procedures that are guided fluoroscopically can be performed using local anaesthesia. Although there was no difference in PD catheter survival between the groups, complication-free PD catheter survival was significantly higher at 42.5%.

Danielsson 2002 compared standard open surgical PD catheter insertion with buried (embedded) to non-buried PD catheters in 60 participants in whom PD start was planned for at least six weeks after PD catheter insertion. PD catheter failure due to mechanical reasons was very low, with only one patient in the buried PD catheter group terminating PD for this reason. There were lower peritonitis rates in the buried group. The Kaplan-Meier curves produced were not sufficiently detailed to be able to extract numerical information. A limitation of this study was that the insertion technique differed slightly between the two centres that participated.

Park 1998 examined 60 patients, randomising to subcutaneous implantation of the PD catheter or to a conventional technique. There was no description of this conventional technique in the methodology section. There was a significant benefit for patients having PD catheter implantation in terms of the frequency of infection (peritonitis or exit site).

Overall completeness and applicability of evidence

Seventeen studies were suitable for inclusion in this review (Figure 1). Major limitations were 1) eight studies could not be meta-analysed, 2) there was only one study in children, and 3) open PD catheter insertion techniques varied. Our primary outcomes - early and long-term PD catheter function - were only reported in three studies. The certainty of the evidence was low or very low.

Quality of the evidence

The quality of study evidence was assessed using the Cochrane risk of bias tool together with GRADE methodology (GRADE 2008; GRADE 2011). There was a high risk of bias in the majority of the examined studies due to difficulties with blinding patients and staff assessing the patients. Randomisation was poorly described or not reported at all in a number of studies (seven studies had an unclear risk of bias, and two studies had a high risk of bias). Several studies did not describe the allocation concealment process, with 10 studies having an unclear risk of bias and two studies having a high risk of bias.

Potential biases in the review process

The Cochrane Kidney and Transplant's Specialised Register was searched up to November 2022. At least two authors independently evaluated all the identified studies in an effort to address any bias or errors in study selection, data extraction and risk of bias assessment. As with most systematic reviews, there remains the possibility that unpublished studies with positive or negative results may not have been identified. We are aware of the potential for publication bias due to the small number of studies in the review.

Agreements and disagreements with other studies or reviews

Several available systematic reviews have examined different techniques of PD catheter insertion. Two reviews examine laparoscopic versus open PD catheter insertion (Hagen 2013; Xie 2012) with differing outcomes. Hagen 2013 found some benefit in terms of one-year PD catheter survival as well as PD catheter migration which is echoed by the findings in the meta-analysis performed for our review (but found to be non-significant; P = 0.14) however, we excluded cohort studies due to the high risk of selection bias in these studies. We also did not examine one-year PD catheter survival as we felt that data could not be extracted accurately from the included studies. Other systematic reviews did not report any issues with data extraction and have reported both one and two-year PD catheter survival. All other currently available systematic reviews also included observational studies (Agarwal 2021; Hagen 2014; Tullavardhana 2016; Xie 2012).

Shrestha 2018 examined non-randomised cohort studies of advanced laparoscopic techniques such as rectus sheath tunnelling and adjunctive procedures (e.g. omentectomy) compared with based laparoscopy and open-surgical insertion, finding benefits for PD catheter migration, PD catheter obstruction, peri-catheter leak and improved PD catheter survival. Since these studies were not randomised, there was a high risk of bias; however, with that caveat, there is the possibility that in the correct hands that the

laparoscopic technique may be superior to basic laparoscopic and open surgical techniques. It is important to note that centres do not always possess the expertise, or indeed the equipment needed, to perform advanced laparoscopic techniques, and we should not discourage centres from offering PD to patients who require dialysis therapy if there are other more widely available techniques with comparable outcomes.

Three systematic reviews compared surgical with medical techniques (Agarwal 2021; Boujelbane 2015; Tullavardhana 2016) that included RCTs and cohort studies (some retrospective), and a meta-analysis was undertaken. There were no significant differences noted in either PD catheter one-year survival or the postoperative complication rates by Boujelbane 2015 and Tullavardhana 2016; however, Agarwal 2021 noted a significant difference in the rates of exit-site infection and early peritonitis. Findings were similar in this review; however, the certainty of the evidence is very low and should be interpreted with caution.

For this review, only RCTs were included. For those medical versus surgical comparisons included (Merrikhi 2014; Gadallah 1999; Qian 2014; Atapour 2011), no long-term survival data was available; however, meta-analysis for some postoperative complications, including early PD catheter failure, could be performed. Our findings agree with previous reviews in that there was no difference in early PD catheter failure in the percutaneous versus open surgical groups. The comparison of peritoneoscopic versus open surgical PD catheter insertion revealed fewer early dialysate leaks; however, this is low certainty evidence.

More recently, a review by Sakurada 2019 examined laparoscopic and open surgical insertion and focused on RCTs only. They did, however, include peritoneoscopic insertion alongside laparoscopic PD catheter insertion. They found no differences in the rate of early PD catheter failure or complications, and it was uncertain whether either technique had any benefit over the other.

AUTHORS' CONCLUSIONS

Implications for practice

The evidence needed to guide physicians in the development of their PD catheter insertion service is lacking. The total number of eligible studies was small, and as previously stated, some techniques have only been examined in small, single-centre RCTs. This increases the risk of imprecision within the studies, and the studies examined had a significant risk of bias, meaning the results should be interpreted with caution. It has been shown, in the UK at least, that there is significant variation between centres in terms of PD catheter survival and outcomes (Hole 2017). This means that small single-centre trials, as contained within this review, are of limited benefit as the centre effect is likely to be so large that differences in the PD catheter survival and postoperative complications cannot be interpreted as significant without further confirmation in other centres.

Many of the studies evaluating PD catheter insertion techniques are small and of poor quality and had inconsistent definitions with regard to postoperative complications (e.g. bleeding episodes and peritonitis episodes). There is a requirement to define acceptable PD catheter outcomes to allow centres to adequately monitor and audit their PD access, and indeed, the most recent iteration of the International Society of Peritoneal Dialysis guideline on PD access has attempted to do this although the literature to support these definitions is sparse (ISPD 2019). None of the included studies adequately reported longer-term outcomes in a way which could be further evaluated by meta-analysis. The techniques used to place the PD catheters varied significantly amongst operators making even those included studies difficult to compare. A further important point is the perioperative management factors strongly influence the approach to PD catheter insertion, and these were not controlled for in the included studies. Perioperative pain is an important outcome which was not examined by the majority of included studies, and overall the number of good-quality studies is low.

The inability to offer a technique should not impact whether PD is offered in a centre. Each centre should develop a pathway for PD catheter insertion based on the local expertise in PD catheter insertion and ensure that appropriate audit measures are in place to monitor individual centre outcomes. Guidelines should reflect this paucity of data regarding PD catheter survival and complications and acknowledge the individual centre experience and expertise.

Implications for research

There remain considerable uncertainties about the optimal way of inserting PD catheters, and further research is needed through either larger multi-centre RCTs or prospective observational studies in order to answer the question as to how PD catheters should be inserted to optimise function. Currently available studies do not consistently report outcomes, particularly PD catheter survival, in a way which can be easily generalisable, and we would therefore suggest standardisation of outcome measures so that further systematic review is easier to perform and interpret.

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CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Atapour 2011

Study characteristics	
Methods	• Study design: RCT • Study duration: 2009 to 2010 • Duration of follow-up: 2 months (60 days)
Participants	Study characteristics • Setting: single centre • Country: Iran • Inclusion criteria: uraemic patients requiring PD • Exclusion criteria: morbid obesity (BMI > 35 kg/m^2); ventral or inguinal hernia; history of abdominal surgery Baseline characteristics • Number (randomised/analysed): percutaneous group (34/31); open surgical group (30/31) • Mean age (years): percutaneous group (58.58 ± 14.7); open surgical group (51.48 ± 19.2) • Sex M/F: percutaneous group (; 21/10); open surgical group (12/18) • Diabetes: percutaneous group (14, 45.2%); open surgical group (14, 44.7%) • Mean BMI ± SD (kg/m^2): percutaneous group (39.7 ± 6.3); open surgical group (38.6 ± 6.3)
Interventions	Intervention group • Percutaneous PD catheter insertion Control group • Open surgical PD catheter insertion
Outcomes	• Peritonitis: within 3 days of PD catheter insertion: measured at days 1, 3, 7 and 14 • Exit-site infection: measured at days 1, 2, 7, 14, 30 and 60 • Postoperative haemorrhage (haemoperitoneum): time point not reported • Leakage from insertion site: time point of measurement not reported • Catheter malposition: time point not reported • Viscus perforation: time point not reported • Incisional hernia: time point not reported • Catheter removal: within the 60-day follow-up period • Operative time: measured at the time of PD catheter insertion
Notes	Other additional information • Funding source: not reported • Exclusions post randomisation: 3 patients excluded from analysis (death due to unrelated causes: cardiac death) • Ethical approval: ethics committee of Isafan University of Medical Sciences (project number 288132)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

Atapour 2011 *(Continued)*

Random sequence generation (selection bias)	Low risk	Random allocation software used to randomise patients
Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	High risk	Not reported; however, operators cannot be blinded to the procedure to be performed
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported whether patients/research staff were blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Selective reporting (reporting bias)	Low risk	All outcomes reported in results
Other bias	Low risk	No conflicts of interest reported

CAPD I 2018

Study characteristics	
Methods	• Study design: RCT • Study duration: 2010 to 2016 • Median duration of follow-up: open surgical group (11 months); laparoscopic group (5 months)
Participants	Study characteristics • Setting: single centre • Country: Netherlands • Inclusion criteria: all patients starting PD; 2nd/3rd PD catheter insertions and patients with previous abdominal surgery included • Exclusion criteria: requiring additional procedure at catheter insertion; life expectancy < 1 year; intra-abdominal malignancy; refusal to take part Baseline characteristics • Number (randomised/analysed): laparoscopic group (49/46); open surgical group (46/44) • Mean age ± SD (years): laparoscopic group (62.6 ± 14.1); open surgical group (64.5 ± 14.1) • Sex M/F: laparoscopic group (29/17); open surgical group (24/20) • Diabetes: laparoscopic group (13, 28%); open surgical group (13, 30%) • Mean BMI ± SD (kg/m^2): laparoscopic group (26.50 ± 5.06); open surgical group (26.05 ± 4.65)
Interventions	Intervention group • Laparoscopic PD catheter insertion Control group • Open surgical PD catheter insertion

CAPD I 2018 *(Continued)*

Outcomes	Primary outcome • Catheter survival: measured at 10, 20, 30 and 40 months Secondary outcomes • Postoperative complications: time of measurement not documented during inpatient stay • Peritonitis • Exit-site infection • Postoperative haemorrhage (incisional haemorrhage/haematoma/blood-stained dialysate) • Dialysate leakage • Cardiac event • Wound infection • Reasons for PD catheter failure: recorded at time of PD catheter failure • Catheter tip malposition • Omental wrapping • Adhesions • Peritonitis > 6 weeks from PD catheter insertion • Bleeding requiring PD catheter removal • Dialysate leakage • Death • Early catheter function: measured 2 to 4 weeks postoperatively • Operation time: measured immediately postoperatively • Additional procedures performed: measured at PD catheter insertion • Hospital stay
Notes	Additional information • Funding source: not reported • Exclusions post randomisation: none reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Sealed non-transparent envelopes
Allocation concealment (selection bias)	Low risk	Envelope selected by non clinical member of team - letter opened on day of operation
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Unable to blind due to nature of procedure
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Dressings applied in a similar way but due to differing positions of incision, further blinding not possible
Incomplete outcome data (attrition bias) All outcomes	Low risk	Transplanted before catheter use (3 patients); lost to follow-up (1); not started treatment after 1 year (1)
Selective reporting (reporting bias)	Low risk	No evidence to support selective reporting

CAPD I 2018 *(Continued)*

Other bias	Unclear risk	Funding source not reported

Chen 2014a

Study characteristics

Methods	• Study design: RCT • Study duration: March 2008 to December 2012 • Duration of follow-up ± SD (days): regular open insertion group (487 ± 174); insertion with an omental folding group (522 ± 133)
Participants	Study characteristics • Setting: single centre • Country: China • Inclusion criteria: patients with ESKD starting CAPD; aged 18 to 80 years; initiation of PD within the study period; presence of greater omentum below the abdominal incision • Exclusion criteria: history of previous open abdominal surgery; history of psychological illness or condition which affects the ability to give informed consent Baseline characteristics • Number (randomised/analysed): omental folding group (34/34); regular open surgical group (33/33) • Mean age ± SD (years): omental folding group (51 ± 13); regular open surgical group (50 ± 14) • Sex M/F: omental folding group (16/18); regular open surgical group (17/16) • Diabetes: not reported • Mean BMI ± SD (kg/m^2): omental folding group (21.5 ± 2.7); regular open surgical group (22.7 ± 3.1)
Interventions	Intervention group • PD catheter insertion with omental folding Control group • Regular open surgical PD catheter insertion
Outcomes	Primary outcomes • Catheter tip migration with catheter failure: measured at < 60 and > 60 days Secondary outcomes • Catheter failure (any cause) • Technique failure: irreversible PD catheter dysfunction, infection, insufficiency of PD, other complications) • Catheter-related infection: peritonitis, tunnel infection, exit-site infection • Postoperative haemorrhage: incisional haemorrhage/haematoma/blood-stained dialysate • Dialysate leakage • Hernia • Catheter survival
Notes	Additional information • Funding source: research award fund for young teachers in Central South University (2011QNZT165) and National Natural Science Foundation of China (No. 81070610)

Chen 2014a *(Continued)*

- Exclusions post randomisation: no exclusions; however, patients were only assessed for eligibility once the procedure was performed
- Ethical approval: Human Research Ethics committee in the Second Xiaangya Hospital of Central South University, China

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Stated to be randomised but no details of how this was done. Patients without omentum were excluded at the time of surgery making prior randomisation difficult
Allocation concealment (selection bias)	High risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	High risk	Not reported; however, operators would not be blinded. Patients were excluded from the study based on intraoperative findings
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Low risk	No evidence of missing data
Selective reporting (reporting bias)	Low risk	No evidence to suggest reporting bias
Other bias	Low risk	Funding from the National Natural Science Foundation of China and the Research Award Fund for Young Teachers

Danielsson 2002

Study characteristics

Methods	• Study design: RCT • Study duration: September 1992 to October 1995 • Mean follow-up period, range (months): buried catheter group (15.5, 0.9 to 44); open, non-buried catheter group (11.9, 0.4 to 33)
Participants	Study characteristics • Setting: 2 centres • Country: Sweden • Inclusion criteria: scheduled to have PD and judged not to require PD for 6 weeks after catheter implantation • Exclusion criteria: requirement for PD within 6 weeks (non-study group) Baseline characteristics • Number (randomised/analysed): buried catheter group (30/30); open, non-buried catheter group (30/30)

Danielsson 2002 *(Continued)*

- Mean age, range (years): buried catheter group (54.6, 32 to 80); open, non-buried catheter group (60.8, 31 to 76)
- Sex (M/F): buried catheter group (18/22); non-buried catheter group (16/14)
- Diabetes: buried catheter group (8, 27%); non-buried catheter group (9, 30%)
- BMI: not reported

Interventions	Intervention group • Buried PD catheter insertion; Moncrieff catheter Control group • Non-buried PD catheter insertion; Moncrieff catheter
Outcomes	Primary outcome • Peritonitis: measured at 6, 12, and 24 months Secondary outcomes • Exit-site infection • Postoperative haemorrhage • Leakage • Catheter occlusion • Omental wrapping • Termination of PD This study also examines the causative organisms in those patients who developed peritonitis/exit-site infection
Notes	Additional information • Funding source: not reported • Exclusions post randomisation: none • Ethical approval: Ethics committee of the Karolinska institute • Non-study group for comparison only: 65 patients received open PD catheter insertion with standard Tenchkoff catheter

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomised but no details given as to how this was performed
Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	High risk	Operator not able to be blinded. The operator in one centre was a nephrologist, in the other centre a surgeon. There are reported differences in the insertion technique depending on operator. Differing anaesthetic used between centres
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Follow-up times vary between groups; no mention of whether outcome assessors were blinded
Incomplete outcome data (attrition bias)	Low risk	No missing data

Danielsson 2002 *(Continued)*
All outcomes

Selective reporting (reporting bias)	Unclear risk	No evidence to suggest reporting bias
Other bias	Unclear risk	No mention of study funding

Ejlersen 1990

Study characteristics

Methods	• Study design: RCT • Study duration: 1 June 1986 to 1 April 1988 • Follow-up period: 1 year
Participants	Study characteristics • Setting: single centre • Country: Denmark • Inclusion criteria: ESKD requiring PD catheter insertion • Exclusion criteria: prior history of extensive peritoneal adherences requiring laparotomy Baseline characteristics • Number (randomised/analysed): midline insertion group (21/21); lateral insertion group (16/16) • Mean age, range (years): midline insertion group (58, 28 to 75); lateral insertion group (57, 28 to 74) • Sex (M/F): midline insertion group (10/11); lateral insertion group (9/7) • Diabetes: not reported • BMI: not reported
Interventions	Intervention group • Lateral incision PD catheter insertion Control group • Midline incision PD catheter insertion
Outcomes	Primary outcome • Catheter survival Secondary outcomes • Surgical/mechanical failure: displacement, leakage, peri-catheter hernia • Infection: tunnel infection; peritonitis • Discontinuation of PD for other reasons: transplantation, death, recovery of kidney function
Notes	• Funding source: not reported • 10 patients were excluded, 7 because the nephrologist or surgeon not aware of the trial, 2 patients refused, 1 unable to give informed consent

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Ejlersen 1990 *(Continued)*

Random sequence generation (selection bias)	High risk	No description of how randomisation took place
Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	No evidence to suggest attrition bias
Selective reporting (reporting bias)	Unclear risk	No evidence to suggest reporting bias
Other bias	Unclear risk	Insufficient information to permit judgement

Gadallah 1999

Study characteristics	
Methods	• Study design: RCT • Study duration: 1992 to 1995 • Follow-up period: 3 years
Participants	Study characteristics • Setting: single centre • Country: USA • Inclusion criteria: ESKD requiring PD catheter insertion (1st catheter insertion only) • Exclusion criteria: not reported Baseline characteristics • Number (randomised/analysed): peritoneoscopy group (76/76); open surgical group (72/72) • Mean age ± SE (years): peritoneoscopy group (45 ± 1.8); open surgical group (47.2 ± 2.4) • Sex (M/F: peritoneoscopy group (37/39); open surgical group (22/34) • Diabetes (diabetic nephropathy): peritoneoscopy group (29, 38.2%), open surgical group (25, 34.7%) • BMI: not reported
Interventions	Intervention group • Peritoneoscopic PD catheter insertion Control group • Open surgical PD catheter insertion
Outcomes	• Early complications: within 2 weeks of PD catheter insertion

Gadallah 1999 *(Continued)*

- Peritonitis
- Leakage
- Catheter malfunction
- Perforation (colon)
- Perforation (bladder)

- Late complications: occurring after 2 weeks
  - Infection
  - Malfunction
  - Hernia
- Death
- Catheter survival: measured at 12, 24 and 36 months

Notes	Additional information • Funding source: not reported • Exclusions post randomisation: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Alternate month randomisation. Clinical team would be aware of the technique for that particular month
Allocation concealment (selection bias)	High risk	Patients were randomised on alternate months meaning that allocation would be difficult to conceal
Blinding of participants and personnel (performance bias) All outcomes	High risk	Patients and personnel would be aware of the insertion technique. No mention is made as to whether the patient or investigators were blinded to the catheter insertion technique. The operator cannot be blinded
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No clear whether investigators were blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Selective reporting (reporting bias)	Low risk	No evidence to suggest reporting bias
Other bias	Unclear risk	Insufficient information to permit judgement

Jwo 2010

Study characteristics

Methods	• Study design: RCT • Study duration: December 2002 to October 2006 • Follow-up period: 1358 days
Participants	Study characteristics

Jwo 2010 *(Continued)*

- Setting: single centre
- Country: Taiwan
- Inclusion criteria: ESKD to receive PD; undergoing first PD catheter placement
- Exclusion criteria: intolerant to spinal/general anaesthesia; refused consent to take part

Baseline characteristics

- Number (randomised/analysed): laparoscopic group (37/37); open surgical group (40/40)
- Mean age ± SD (years): laparoscopic group (56.7 ± 13.4); open surgical group (54.4 ± 16.5)
- Sex (M/F): laparoscopic group (12/25); open surgical group (18/22)
- Diabetes: laparoscopic group (14, 38%); open surgical group (12, 30%)
- BMI ± SD (kg/m^2): laparoscopic group (22.99 ± 4.44); open surgical group (22.73 ± 4.07)

Interventions	Intervention group • Laparoscopic PD catheter insertion Control group • Open surgical PD catheter insertion

Outcomes	• Early procedural complications: within 4 weeks of PD catheter insertion
	  ○ Catheter migration
	  ○ Dialysate leakage
	  ○ Peri-cannular bleeding
	  ○ Exit-site infection
	  ○ Peritonitis
	• Late procedural complications: > 4 weeks post PD catheter insertion
	  ○ Catheter migration
	  ○ Dialyate leakage
	  ○ Exit-site infection
	  ○ Peritonitis
	• Hernia
	• Postoperative pain
	• Operative time
	• Mean catheter survival

Notes	Additional information • Funding source: Grant awarded from Chang Gung Memorial Hospital (contract no. CMRPG2015) • Exclusions post randomisation: none • End points: not reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: “each enrolled patient was randomly assigned to either the open group or the laparoscopic group” There is no description of how this randomisation was carried out or by whom
Allocation concealment (selection bias)	Unclear risk	Although patients were randomly allocated to a group, there is no description of whether allocation was concealed from the clinical team or patient

Jwo 2010 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	High risk	Personnel performing the procedure cannot be blinded to the type of procedure they will be carrying out. The operator (surgeon) was not involved in the randomisation process
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated whether investigators were blinded as to the insertion technique used to put in the PD catheter
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Selective reporting (reporting bias)	Low risk	No evidence to suggest this
Other bias	Low risk	Study funding provided by the Chang Gung Memorial hospital

Li 2010c

Study characteristics	
Methods	• Study design: RCT • Study duration: January 2011 to April 2011 • Follow-up period: not reported
Participants	Study characteristics • Setting: single centre • Country: China • Inclusion criteria: ESKD to receive PD • Exclusion criteria: not reported Baseline characteristics • Number: 74 (numbers per group not reported) • Mean age: not reported • Sex M/F: not reported • Diabetes: not reported • BMI: not reported
Interventions	Intervention group • Laparoscopic PD catheter insertion Control group • Open surgical PD catheter insertion

Outcomes	• Complications: time point of measurement not stated
	  ○ Dialysate leakage
	  ○ Bleeding
	  ○ Catheter displacement
	  ○ Exit-site infection
	• Peritonitis

Li 2010c *(Continued)*

- Death
- Mean operative cost
- Mean hospital expense

Notes	Additional information • Abstract-only publication • Funding source: not reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information to permit judgement
Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Selective reporting (reporting bias)	Low risk	Nothing to suggest reporting bias from the limited information available
Other bias	Unclear risk	Insufficient information to permit judgement

Merrikhi 2014

Study characteristics

Methods	• Study design: RCT • Study duration: 2010 to 2011 • Duration of follow-up: 60 days
Participants	Study characteristics • Setting: single centre • Country: Iran • Inclusion criteria: < 15 years; ESKD requiring PD • Exclusion criteria: history of major abdominal surgery; ventral or inguinal hernia; BMI > 35 Baseline characteristics • Number (randomised/analysed): percutaneous group (18/18); open surgical group (17/17) • Mean age ± SD (years): percutaneous group (6.77 ± 4.87); open surgical group (6.38 ± 4.91)

Merrikhi 2014 *(Continued)*

- Sex (M/F): percutaneous group (9/9); open surgical group (12/5)
- Diabetes: not reported
- BMI (kg/m^2): percutaneous group (16.8 ± 1.31); open surgical group (14.8 ± 1.33)

Interventions	Intervention group • Percutaneous PD catheter insertion Control group • Open surgical PD catheter insertion
Outcomes	Outcomes measured at 3, 7, 14, 30 and 60 days post PD catheter insertion • Catheter-related infection • Haemoperitoneum • Catheter malposition • Incisional hernia • Wrapped omentum • Hollow viscus perforation • Duration of operation • Duration of hospital stay
Notes	Additional information • Funding source: not reported • Exclusions post randomisation: none • End-points: not reported • Trial registration: Iranian Registry of Clinical Trials, 2013091514670N1

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Random allocation software used for allocation
Allocation concealment (selection bias)	Low risk	No evidence to indicate selection bias
Blinding of participants and personnel (performance bias) All outcomes	High risk	Operator could not be blinded
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No description of whether patients/other personnel blinded to insertion technique
Incomplete outcome data (attrition bias) All outcomes	Low risk	Outcomes reported for all recruited patients
Selective reporting (reporting bias)	Low risk	No evidence to suggest selective reporting
Other bias	Low risk	Support from Isfahan University

Park 1998

Study characteristics	
Methods	• Study design: RCT • Study duration: April 1991 to January 1995 • Follow-up period: up to 2 years after PD catheter insertion
Participants	Study characteristics • Setting: single centre • Country: South Korea • Inclusion criteria: ESKD requiring PD catheter insertion • Exclusion criteria: not reported Baseline characteristics • Number (randomised/analysed): subcutaneous implantation group (30/30); conventional group (30/29) • Mean age, range (years): subcutaneous implantation group (47.8, 16 to 69); conventional group (46.2, 27 to 71) • Sex (M/F): subcutaneous implantation group (19/11); conventional group (17/12) • Diabetes: subcutaneous implantation group (13, 43.3%); conventional group (13, 44.8%) • BMI: not reported
Interventions	Intervention group • Subcutaneous PD catheter implantation Control group • Conventional PD catheter insertion
Outcomes	Primary outcome • Peritonitis: recorded at the time of diagnosis; no fixed time points reported Secondary outcomes • Exit-site infection • Simultaneous peritonitis and exit-site infection • Technique failure (results not reported) • Death • Catheter obstruction • Dialysate leakage
Notes	Additional information • Funding source: not reported

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information to permit judgement

Park 1998 *(Continued)*

Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Low risk	No evidence of attrition bias
Selective reporting (reporting bias)	Low risk	No suggestion of reporting bias
Other bias	Unclear risk	Insufficient information to permit judgement

Qian 2014

Study characteristics	
Methods	• Study design: RCT • Study duration: March 2009 to November 2012 • Follow-up period: 2.5 years
Participants	Study characteristics • Setting: single centre • Country: China • Inclusion criteria: ESKD requiring PD catheter insertion • Exclusion criteria: not reported Baseline characteristics • Number (randomised/analysed): cystoscopic-assisted group (14/14); open surgical group (15/15) • Mean age ± SD (years): cystoscopic-assisted group (60.2 ± 5.7); open surgical group (62.7 ± 8.6) • Sex (M/F) cystoscopic-assisted group (6/8); open surgical group (7/8) • Diabetes (diabetic nephropathy): cystoscopic-assisted group (4, 28.6%); open surgical group (3, 20.0%) • BMI: not reported
Interventions	Treatment group • Cystoscopy-assisted PD catheter insertion Control group • Open surgical PD catheter insertion

Outcomes	• Surgical complications: time points not recorded
	  ○ Catheter obstruction
	  ○ Peritonitis

Qian 2014 *(Continued)*

- Exit-site infection
- Dialysate leakage
- Catheter tip migration
- Hernia

- Operative time
- Hospital stay
- Length of incision

Notes	Additional information • Funding source: not reported • Exclusions post randomisation: none • End-points: not reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No description of randomisation process
Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	High risk	Operator could not be blinded. No description of blinding of either patients or investigating personnel
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Selective reporting (reporting bias)	High risk	The authors describe survival analysis but do not present this data.
Other bias	Unclear risk	No study funding reported however no conflict of interest declared

Shahbandari 2019

Study characteristics

Methods	• Study design RCT • Study duration: 2016 to 2017 • Follow-up period: 12 months
Participants	Study characteristics • Setting: single centre • Country: Iran • Inclusion criteria: ESKD requiring PD catheter insertion

Shahbandari 2019 *(Continued)*

- Exclusion criteria: unfit for anaesthesia

Baseline characteristics

- Number (randomised/analysed): laparoscopic group (60/60); open surgical group (61/61)
- Mean age ± SD (years): laparoscopic group (56.95 ± 17.21); open surgical group (55.54 ± 18.13)
- Sex (M/F): laparoscopic group (40/20); open surgical group (38/23)
- Diabetes: not reported
- BMI: not reported

Interventions	Intervention group • Laparoscopic PD catheter insertion Control group • Open surgical PD catheter insertion

Outcomes	• Surgical complications: assessed in those PD catheters surviving > 1 year
	  ○ Catheter obstruction
	  ○ Peritonitis (early/late): early measured < 4 weeks, late measure as > 4 weeks post insertion
	  ○ Exit-site infection
	  ○ Dialysate leakage
	  ○ Catheter movement
	  ○ Hernia
	• Hospital stay
	• 12-month PD catheter survival
	• Death: those patients with catheter failure < 12 months

Notes	Additional information • Funding source: the study was sponsored by Isfahan University of Medical Sciences • Ethical approval: approved by the Ethical Committee of Isfahan School of Medicine (code: 396,183) • Trial registration: Iranian Registry of Clinical Trials (code: IRCT20190525043691N1)

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Use of random allocation software
Allocation concealment (selection bias)	Low risk	Use of random allocation software
Blinding of participants and personnel (performance bias) All outcomes	High risk	Personnel not able to be blinded to the procedure
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data

Shahbandari 2019 *(Continued)*

Selective reporting (reporting bias)	Low risk	No suggestion of reporting bias
Other bias	Low risk	No conflict of interest declared

Tsimoyiannis 2000

Study characteristics

Methods	• Study design: RCT • Study duration: not reported • Follow-up period: 36 months
Participants	Study characteristics • Setting: single centre • Country: Greece • Inclusion criteria: ESKD; adults undergoing PD catheter insertion • Exclusion criteria: unfit for general anaesthesia Baseline characteristics • Number (randomised/analysed): laparoscopic group (25/25); open surgical group (26/20) • Mean age, range (years): laparoscopic group (58, 25 to 75); open surgical group (62, 48 to 72) • Sex (M/F): laparoscopic group (18/7); open surgical group (16/4) • Diabetes: not reported • BMI: not reported
Interventions	Intervention group • Laparoscopic PD catheter insertion Control group • Open surgical PD catheter insertion
Outcomes	• Peritonitis: postoperative peritonitis recorded, but no documentation of specific time point • Leakage • Catheter tip migration • Catheter removal • Operative time • Additional procedures
Notes	Additional information • Funding source: not reported • Exclusions post randomisation: 6 in the open surgical group

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Closed envelope randomisation to group

Tsimoyiannis 2000 *(Continued)*

Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	High risk	Patients/personnel could not be blinded due to differing anaesthetics between groups. Patients receiving laparoscopy would receive general anaesthetic and patients in the open surgical group would only receive a local anaesthetic
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated whether assessors were blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Selective reporting (reporting bias)	Unclear risk	There is no clear evidence of selective reporting however the number of reported outcomes is less than in other studies
Other bias	Unclear risk	No study funding or conflict of interests declared

Voss 2012

Study characteristics	
Methods	• Study design: RCT • Study duration: 1 April 1999 to 30 August 2004 • Follow-up period: 365 days

Participants	Study characteristics
	• Setting: single centre
	• Country: New Zealand
	• Inclusion criteria: ESKD accepting PD as dialysis modality
	• Exclusion criteria: severe obesity BMI > 35; previous abdominal surgery; history consistent with adhesions; severe medical co-morbidity precluding general anaesthesia; immunosuppression; HIV infection; severe psychiatric disease; plans for live donor transplantation
	Baseline characteristics
	• Number (randomised/analysed): radiological group (57/57); laparoscopic group (56/56)
	• Mean age, range (years): radiological group (61.1, 53.3 to 71.4); laparoscopic group (60.8, 51 to 69.7)
	• Sex (M/F): radiological group (28/29); laparoscopic group (30/26)
	• Diabetes
	  ◦ Type 1: radiological group (2, 3.5%); laparoscopic group (0)
	  ◦ Type 2: radiological group (28, 49.1%); laparoscopic group (29, 50%)
	• Mean BMI, range (kg/m^2): radiological group (27, 24.5 to 30.7); laparoscopic group (26.4, 23.7 to 30.1)

Interventions	Intervention group • Fluoroscopic PD catheter insertion Control group • Laparoscopic PD catheter insertion

Voss 2012 *(Continued)*

Outcomes	Primary endpoint: occurrence of catheter-related complications at day 365 (composite endpoint including mechanical and infectious complications). Early complications were defined as those occurring within 60 days of PD catheter insertion • Peritonitis • Exit-site infection • Patency failure • Postoperative haemorrhage • Dialysate leakage • Catheter tip migration Secondary endpoints • Catheter removal (any cause) • Death by day 365 • Procedure room utilization time (operative time) • Length of inpatient admission • Procedure pain • Direct hospital costs
Notes	Additional information • Funding source: none declared • Exclusions post randomisation: fluoroscopic group (6); laparoscopic group (5) • Ethical approval: Northern NZ ethics committee; study registration ISRCTN92892834

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Sequentially numbered envelopes
Allocation concealment (selection bias)	Low risk	Allocations stored in opaque sealed envelopes unavailable to investigators and study research staff
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Performed by research staff not involved in patient care. Unable to blind completely as patient and operator must be aware of type of procedure (differing anaesthetic)
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessors could determine the technique used based on the anaesthetic used; however, the data analysts were blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Selective reporting (reporting bias)	Low risk	No evidence to suggest reporting bias
Other bias	Unclear risk	No conflicts of interest reported but no study funding declared

Wright 1999

Study characteristics	
Methods	• Study design: RCT • Study duration: not reported • Follow-up period: laparoscopic (265 months); open surgical (361 months)
Participants	Study characteristics • Setting: single centre • Country: UK • Inclusion criteria: ESKD; starting PD; suitable for general anaesthetic • Exclusion criteria: not reported Baseline characteristics • Number (randomised/analysed): laparoscopic group (25/21); open surgical group (25/24) • Mean age ± SD (years): laparoscopic group (46.4 ± 14.8); open surgical group (49.3 ± 20.2) • Sex (M/F): 14/7 laparoscopic group (14/7); open surgical group (15/9) • Diabetes: not reported • Mean BMI ± SD (kg/m^2): laparoscopic group (27.7 ± 7.9); open surgical group (25.3 ± 3.5)
Interventions	Intervention group • Laparoscopic PD catheter insertion Control group • Open surgical PD catheter insertion

Outcomes	Early complications defined as within 6 weeks of PD catheter insertion; late complications defined as more than 6 weeks post PD catheter insertion
	• Complications
	  ○ Peritonitis
	  ○ Exit-site infection
	  ○ Dialysate leakage
	  ○ Catheter removal
	  ○ Mechanical failure
	  ○ Catheter tip migration
	• Catheter survival
	• Postoperative pain scores
	• Operative time

Notes	Additional information • Not reported whether first or subsequent catheter • Funding source: not reported • Exclusions post randomisation: laparoscopic group (5; conversion to an open procedure); open surgical group (1; complication unrelated to PD) • End-points: not reported

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

Wright 1999 *(Continued)*

Random sequence generation (selection bias)	Low risk	Quote: “Randomisation was by sealed envelopes containing cards with “laparoscopic” or “conventional” written on them.”
Allocation concealment (selection bias)	Low risk	Randomisation performed at time of PD catheter insertion Quote: "These cards were stored in the theatre anaesthetic room and one envelope opened after each patient was anaesthetised, thus blinding the patient to the procedure performed.”
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of patients and nursing staff Quote: "These cards were stored in the theatre anaesthetic room and one envelope opened after each patient was anaesthetised, thus blinding the patient to the procedure performed.”
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated whether investigators blinded to the method of insertion Measures were taken so the nurses assigned to collect pain scores following the catheter insertion were not aware of which catheter insertion method had been used Unclear who recorded other outcomes
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Patients unsuitable for the laparoscopic procedure were excluded and data not reported
Selective reporting (reporting bias)	Low risk	No evidence of selective reporting
Other bias	Unclear risk	No study funding declared

Zhang 2016

Study characteristics	
Methods	• Study design: RCT • Study duration: January 2013 to December 2015 • Follow-up period: 6 months after surgery
Participants	Study characteristics • Setting: single centre • Country: China • Inclusion criteria: ESKD; starting PD • Exclusion criteria: contraindications to PD; refused PD Baseline characteristics • Number (randomised/analysed): modified open surgical group (49/49); modified open surgical + fixation group (54/54); traditional open surgical group (49/49) • Mean age ± SD (years): modified open surgical group (55.9 ± 17.1); modified open surgical + fixation group (57.2 ± 16.6); traditional open surgical group (53.8 ± 19.0) • Sex (M/F): modified open surgical group (29/20); modified open surgical + fixation group (32/22); traditional open surgical group (31/18) • Diabetes: not reported (although diabetic kidney disease patients recorded as primary kidney disease)

Zhang 2016 *(Continued)*

	• Mean BMI ± SD (kg/m²): modified open surgical group (22.5 ±2.7); modified open surgical + fixation group (23.0 ± 1.8); traditional open surgical group (22.7 ± 1.9)
Interventions	Intervention group 1 • Modified open surgical PD catheter insertion Intervention group 2 • Modified open surgical PD catheter insertion + fixation Control group • Traditional open surgical PD catheter insertion

Outcomes	• Operative time
	• Complications (assessed at 1 year post PD catheter insertion)
	  ○ Catheter malfunction: primary endpoint
	  ○ migration
	  ○ non-migration
	  ○ Peritonitis
	  ○ Exit-site and tunnel infection
	  ○ Dialysate leakage
	  ○ Bleeding
	  ○ Hernia
	  ○ Catheter survival
	  ○ Delayed wound healing
	  ○ Inflow/outflow pain

Notes	Additional information • Not reported whether first or subsequent catheter • Funding source: work supported by the National natural science Foundation of China (81500537) • Exclusions post randomisation: none reported • Ethical approval: local ethics committee approval

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation was performed by a computer generated random number table
Allocation concealment (selection bias)	Unclear risk	Not stated how allocations were communicated to staff responsible for patient care
Blinding of participants and personnel (performance bias) All outcomes	High risk	Unable to blind
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No mention of blinding at follow-up
Incomplete outcome data (attrition bias)	Low risk	No patients lost to follow-up as far as we can tell from the published report

Zhang 2016 *(Continued)*

All outcomes

Selective reporting (reporting bias)	Unclear risk	No evidence of selective reporting
Other bias	Unclear risk	No conflict of interest declared

Zhu 2015

Study characteristics	
Methods	• Study design: RCT • Study duration: March 2010 to March 2013 • Follow-up period: 1 year
Participants	Study characteristics • Setting: single centre • Country: China • Inclusion criteria: ESKD; starting PD • Exclusion criteria: not reported Baseline characteristics • Number (randomised/analysed): 'Mini-Perc' surgical group (35/35); open surgical group (37/37) • Mean age ± SD (years): 'Mini-Perc' surgical group (54.3 ± 16.2); open surgical group (56.8 ± 14.7) • Sex (M/F): 'Mini-Perc' surgical group (21/14); open surgical group (25/12) • Diabetes: not reported (although diabetic kidney disease recorded as primary kidney disease) • Mean BMI ± SD (kg/m^2): 'Mini-Perc' surgical group (23.2 ± 3.8); open surgical group (22.7 ± 4.3)
Interventions	Intervention group • 'Mini-Perc' surgical PD catheter insertion Control group • Open surgical PD catheter insertion

Outcomes	• Incision size
	• Length of operation
	• Length of hospital stay
	• Complications (assessed at 1 year post PD catheter insertion):
	  ○ Catheter malfunction
	  ○ Peritonitis
	  ○ Exit-site and tunnel infection
	  ○ Dialysate leakage
	  ○ Bleeding/blood transfusion
	  ○ Hernia
	  ○ Catheter survival
	  ○ Delayed wound healing
	  ○ Inflow/outflow pain

Notes	Additional information • Not reported whether first or subsequent catheter

Zhu 2015 *(Continued)*

- Funding source: not reported
- No reported exclusions post-randomisation
- Local ethical approval granted

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Groups unbalanced - all patients with previous surgery have been randomised to the intervention technique. No patients with previous surgery underwent standard open surgical PD catheter insertion
Allocation concealment (selection bias)	Unclear risk	Not stated how the allocation concealed from patients/assessors (operator cannot be blinded)
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not stated whether patients or study personnel blinded after allocation
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated whether study assessors blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	No evidence of attrition bias
Selective reporting (reporting bias)	Low risk	No evidence of selective reporting
Other bias	Unclear risk	No conflict of interest declared

BMI: body mass index; CAPD: continuous ambulatory peritoneal dialysis; ESKD: end-stage kidney disease; M/F: male/female; PD: peritoneal dialysis; RCT: randomised controlled trial; SD: standard deviation; SE: standard error

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Ahmad 2010	Other: unavailable to locate published study
Al-Hwiesh 2016	Wrong intervention: PD catheter was modified which may have affected the outcomes
ChiCTR-TRC-11001848	Wrong intervention: comparing site of insertion rather than technique
Eklund 1994	Wrong intervention: comparing catheter types rather than catheter insertion technique
ISRCTN87054124	Study terminated: registered but never performed
Li 2009e	Wrong intervention: comparison of catheter types
Misiolek 2012	Wrong intervention: CVC insertion
N0547061060	Study terminated: registered but never performed

Study	Reason for exclusion
NCT01023191	Study terminated: registered but never performed
Nielsen 1995	Wrong intervention: comparing catheter types, not catheter insertion technique
Rubin 1990	Wrong intervention: comparing catheter insertion site rather than technique
Stegmayr 2015	Wrong intervention: comparing catheter type rather than insertion technique
Sun 2015a	Wrong intervention: compared tunnel direction and not catheter implantation technique
Valdivia-Gomez 2004	Wrong intervention: not a comparison of insertion techniques
Yip 2010	Wrong intervention: comparing catheter type and tunnel direction

CVC: central venous catheter; PD: peritoneal dialysis

Characteristics of studies awaiting classification *[ordered by study ID]*

Talwar 2021

Methods	• Study design: RCT • Study duration: August 2016 to March 2018 • Duration of follow-up: 6 weeks
Participants	Study characteristics • Setting: single centre • Country: India • Inclusion criteria: undergoing PD catheter insertion • Exclusion criteria: not reported Baseline characteristics • Number (randomised/analysed): laparoscopic group (25/25); open surgical group (25/25) • Mean age ± SD (years): laparoscopic group (50.88 ± 7.59); open surgical group (55.12 ± 8.54) • Sex (M/F): laparoscopic group (18/7); open surgical group (19/6) • Diabetes: not reported • BMI (kg/m^2): laparoscopic group (20-23 (2), 23.1-25 (2), 25.1-27 (14), > 27 (7)); open surgical group (20-23 (1), 23.1-25 (8), 25.1-27 (13), > 27 (3))
Interventions	Intervention group • Laparoscopic catheter insertion Control group • Open catheter insertion
Outcomes	• Postoperative pain scores (days 0 to 7) • Readmission • Leakage • Death • Catheter migration • Peritonitis • Catheter site infection

Talwar 2021 *(Continued)*	• Catheter status at 6 weeks
Notes	

BMI: body mass index; M/F: male/female; PD: peritoneal dialysis; RCT: randomised controlled trial; SD: standard deviation

Characteristics of ongoing studies *[ordered by study ID]*

CTRI/2018/02/011871

Study name	Does laparoscopic omentectomy reduce CAPD catheter malfunction: A three-arm pilot randomized trial
Methods	Parallel, pilot RCT (3-arm)
Participants	Consecutive patients, aged 1 to 80 years, referred from the Department of Nephrology for PD catheter insertion
Interventions	Group A • Laparoscopic PD catheter insertion with omentectomy under general anaesthesia Group B • Laparoscopic PD catheter insertion without omentectomy under general anaesthesia Group C • Conventional open surgical PD catheter insertion under local anaesthesia
Outcomes	Primary outcome • Incidence of catheter malfunction at 6 weeks and 3 months. Malfunction was defined as the presence of inflow or outflow restriction Secondary outcomes • Operating time and complications
Starting date	September 2017 to September 2019
Contact information	S. Vuthaluru, Department of Surgical Disciplines, All India Institute of Medical Sciences, New Delhi - 110 029, India
Notes	

LOCI 2011

Study name	Laparoscopic versus open peritoneal dialysis catheter insertion - LOCI-trial
Methods	Multicentre RCT
Participants	Dutch speaking patients eligible for PD
Interventions	Intervention group • Laparoscopic PD catheter insertion

LOCI 2011 *(Continued)*

	Control group • Open surgical PD catheter insertion
Outcomes	Primary outcome • Percentage of functioning PD catheters at 6 weeks Secondary outcomes • Catheter longevity • Rate of surgical complications • Death • Leakage • Catheter migration • Re-admissions • Infections • Duration of hospital stay • QoL • Pain score • Use of postoperative pain medication • Percentage of functioning PD catheters at 6 months postoperatively
Starting date	Not reported
Contact information	s.hagen@erasmusmc.nl Department of Surgery, Erasmus MC, University Medical Center, Rotterdam, The Netherlands. PO BOX 2040, 3000 CA, Rotterdam, The Netherlands
Notes	

CAPD: continuous ambulatory peritoneal dialysis; PD: peritoneal dialysis; QoL: quality of life; RCT: randomised controlled trial

DATA AND ANALYSES

Comparison 1. Laparoscopic versus open surgical PD catheter insertion

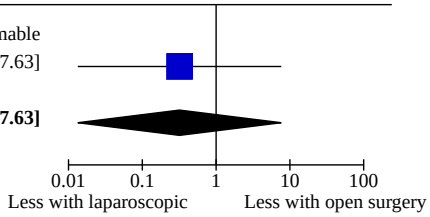
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.1 Postoperative death	2	167	Risk Ratio (M-H, Random, 95% CI)	0.32 [0.01, 7.63]
1.2 Exit-site infection	3	212	Risk Ratio (M-H, Random, 95% CI)	1.10 [0.59, 2.06]
1.3 Peritonitis	4	288	Risk Ratio (M-H, Random, 95% CI)	0.97 [0.63, 1.48]
1.4 PD catheter removal (any cause)	4	257	Risk Ratio (M-H, Random, 95% CI)	1.15 [0.80, 1.64]
1.5 Haemorrhage	2	167	Risk Ratio (M-H, Random, 95% CI)	1.68 [0.28, 10.31]
1.6 Catheter tip migration	4	333	Risk Ratio (M-H, Random, 95% CI)	0.43 [0.20, 0.92]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.7 Dialysate leakage	5		Risk Ratio (M-H, Random, 95% CI)	Subtotals only
1.7.1 All studies	5	378	Risk Ratio (M-H, Random, 95% CI)	0.92 [0.22, 3.93]
1.7.2 Excluding Tsimoyiannis 2000	4	330	Risk Ratio (M-H, Random, 95% CI)	1.40 [0.49, 4.02]

Analysis 1.1. Comparison 1: Laparoscopic versus open surgical PD catheter insertion, Outcome 1: Postoperative death

Study or Subgroup	Laparoscopic Events	Laparoscopic Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
Jwo 2010	0	37	0	40		Not estimable
CAPD I 2018	0	46	1	44	100.0%	0.32 [0.01 , 7.63]
Total (95% CI)		**83**		**84**	**100.0%**	**0.32 [0.01 , 7.63]**
Total events:	0		1			

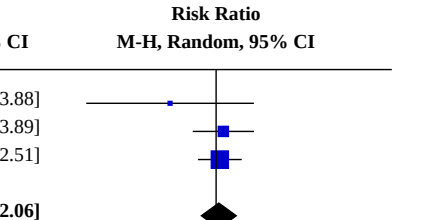
Heterogeneity: Not applicable
Test for overall effect: Z = 0.71 (P = 0.48)
Test for subgroup differences: Not applicable



Analysis 1.2. Comparison 1: Laparoscopic versus open surgical PD catheter insertion, Outcome 2: Exit-site infection

Study or Subgroup	Laparoscopic Events	Laparoscopic Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
CAPD I 2018	0	46	2	44	4.3%	0.19 [0.01 , 3.88]
Jwo 2010	6	37	5	40	32.3%	1.30 [0.43 , 3.89]
Wright 1999	8	21	8	24	63.3%	1.14 [0.52 , 2.51]
Total (95% CI)		**104**		**108**	**100.0%**	**1.10 [0.59 , 2.06]**
Total events:	14		15			

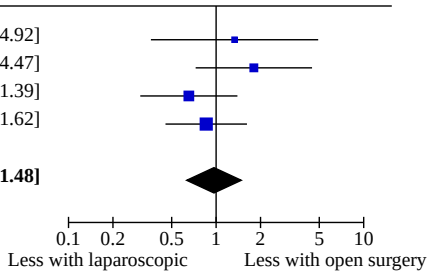
Heterogeneity: Tau² = 0.00; Chi² = 1.44, df = 2 (P = 0.49); I² = 0%
Test for overall effect: Z = 0.31 (P = 0.76)
Test for subgroup differences: Not applicable



Analysis 1.3. Comparison 1: Laparoscopic versus open surgical PD catheter insertion, Outcome 3: Peritonitis

Study or Subgroup	Laparoscopic Events	Laparoscopic Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
Tsimoyiannis 2000	5	25	3	20	10.3%	1.33 [0.36 , 4.92]
Jwo 2010	10	37	6	40	20.7%	1.80 [0.73 , 4.47]
Shahbandari 2019	9	60	14	61	29.0%	0.65 [0.31 , 1.39]
Wright 1999	9	21	12	24	39.9%	0.86 [0.45 , 1.62]
Total (95% CI)		**143**		**145**	**100.0%**	**0.97 [0.63 , 1.48]**
Total events:	33		35			

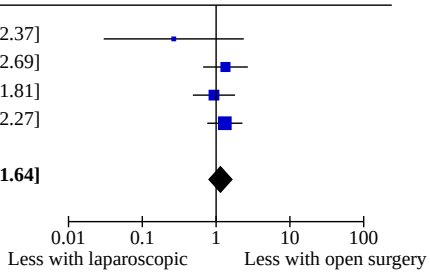
Heterogeneity: Tau² = 0.01; Chi² = 3.21, df = 3 (P = 0.36); I² = 7%
Test for overall effect: Z = 0.15 (P = 0.88)
Test for subgroup differences: Not applicable



Analysis 1.4. Comparison 1: Laparoscopic versus open surgical PD catheter insertion, Outcome 4: PD catheter removal (any cause)

Study or Subgroup	Laparoscopic Events	Laparoscopic Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
Tsimoyiannis 2000	1	25	3	20	2.7%	0.27 [0.03 , 2.37]
CAPD I 2018	14	46	10	44	26.0%	1.34 [0.67 , 2.69]
Wright 1999	9	21	11	24	29.2%	0.94 [0.48 , 1.81]
Jwo 2010	17	37	14	40	42.1%	1.31 [0.76 , 2.27]
Total (95% CI)		**129**		**128**	**100.0%**	**1.15 [0.80 , 1.64]**
Total events:	41		38			

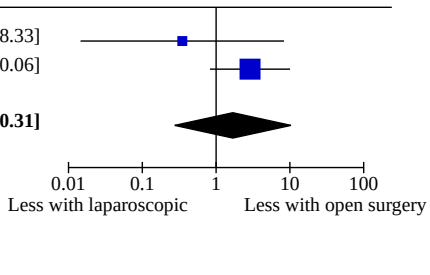
Heterogeneity: Tau² = 0.00; Chi² = 2.52, df = 3 (P = 0.47); I² = 0%
Test for overall effect: Z = 0.75 (P = 0.45)
Test for subgroup differences: Not applicable



Analysis 1.5. Comparison 1: Laparoscopic versus open surgical PD catheter insertion, Outcome 5: Haemorrhage

Study or Subgroup	Laparoscopic Events	Laparoscopic Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
CAPD I 2018	0	44	1	46	25.4%	0.35 [0.01 , 8.33]
Jwo 2010	8	37	3	40	74.6%	2.88 [0.83 , 10.06]
Total (95% CI)		**81**		**86**	**100.0%**	**1.68 [0.28 , 10.31]**
Total events:	8		4			

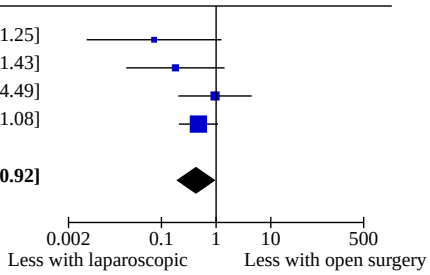
Heterogeneity: Tau² = 0.74; Chi² = 1.49, df = 1 (P = 0.22); I² = 33%
Test for overall effect: Z = 0.56 (P = 0.57)
Test for subgroup differences: Not applicable



Analysis 1.6. Comparison 1: Laparoscopic versus open surgical PD catheter insertion, Outcome 6: Catheter tip migration

Study or Subgroup	Laparoscopic Events	Laparoscopic Total	Open Surgery Events	Open Surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
Tsimoyiannis 2000	0	25	5	20	7.1%	0.07 [0.00 , 1.25]
Jwo 2010	1	37	6	40	12.9%	0.18 [0.02 , 1.43]
CAPD I 2018	3	46	3	44	21.8%	0.96 [0.20 , 4.49]
Shahbandari 2019	7	60	15	61	58.3%	0.47 [0.21 , 1.08]
Total (95% CI)		**168**		**165**	**100.0%**	**0.43 [0.20 , 0.92]**
Total events:	11		29			

Heterogeneity: Tau² = 0.09; Chi² = 3.40, df = 3 (P = 0.33); I² = 12%
Test for overall effect: Z = 2.16 (P = 0.03)
Test for subgroup differences: Not applicable



Analysis 1.7. Comparison 1: Laparoscopic versus open surgical PD catheter insertion, Outcome 7: Dialysate leakage

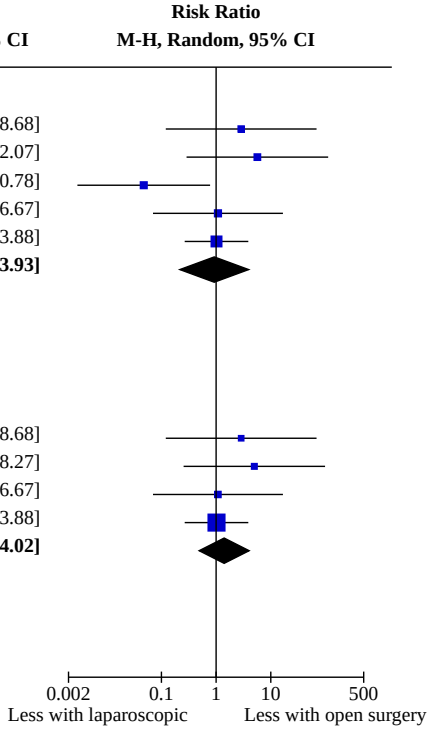
Study or Subgroup	Laparoscopic Events	Laparoscopic Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
1.7.1 All studies						
CAPD I 2018	1	46	0	44	14.6%	2.87 [0.12 , 68.68]
Wright 1999	2	21	0	24	15.9%	5.68 [0.29 , 112.07]
Tsimoyiannis 2000	0	25	8	20	17.3%	0.05 [0.00 , 0.78]
Jwo 2010	1	37	1	40	17.8%	1.08 [0.07 , 16.67]
Shahbandari 2019	4	60	4	61	34.4%	1.02 [0.27 , 3.88]
Subtotal (95% CI)		**189**		**189**	**100.0%**	**0.92 [0.22 , 3.93]**
Total events:	8		13			

Heterogeneity: Tau² = 1.12; Chi² = 6.90, df = 4 (P = 0.14); I² = 42%
Test for overall effect: Z = 0.11 (P = 0.92)

1.7.2 Excluding Tsimoyiannis 2000						
CAPD I 2018	1	46	0	44	11.0%	2.87 [0.12 , 68.68]
Wright 1999	2	21	0	21	12.5%	5.00 [0.25 , 98.27]
Jwo 2010	1	37	1	40	14.8%	1.08 [0.07 , 16.67]
Shahbandari 2019	4	60	4	61	61.7%	1.02 [0.27 , 3.88]
Subtotal (95% CI)		**164**		**166**	**100.0%**	**1.40 [0.49 , 4.02]**
Total events:	8		5			

Heterogeneity: Tau² = 0.00; Chi² = 1.18, df = 3 (P = 0.76); I² = 0%
Test for overall effect: Z = 0.63 (P = 0.53)

Test for subgroup differences: Chi² = 0.21, df = 1 (P = 0.65), I² = 0%



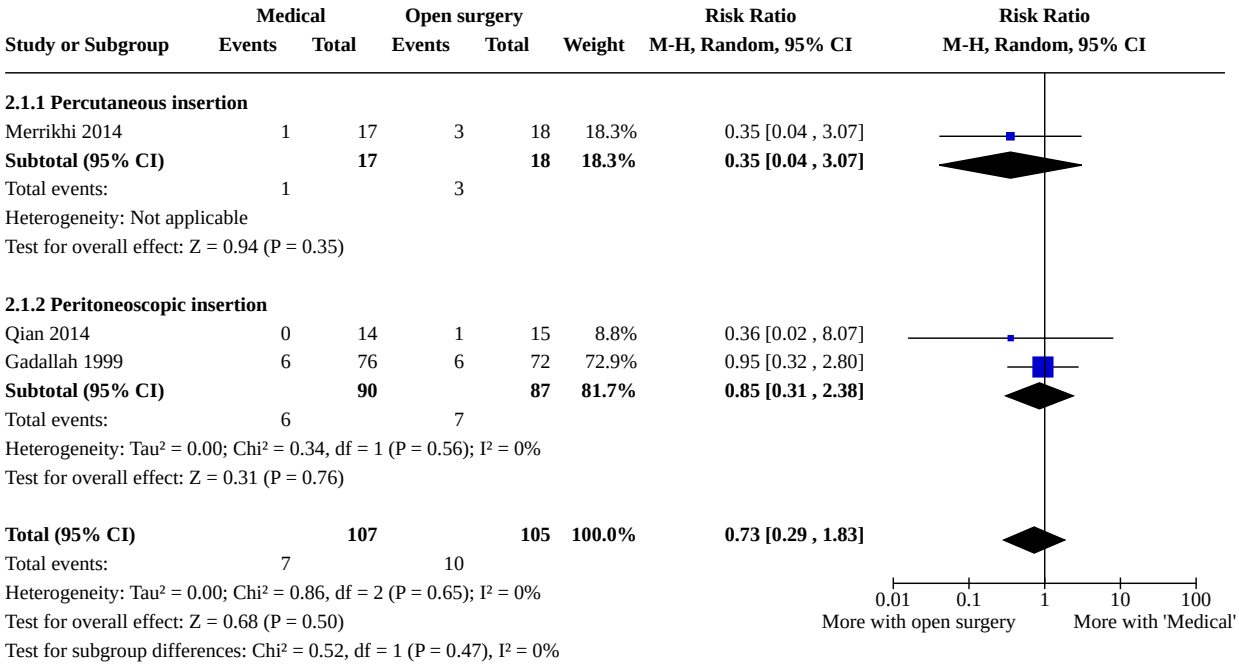
Comparison 2. Medical versus open surgical PD catheter insertion

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.1 Early PD catheter function	3	212	Risk Ratio (M-H, Random, 95% CI)	0.73 [0.29, 1.83]
2.1.1 Percutaneous insertion	1	35	Risk Ratio (M-H, Random, 95% CI)	0.35 [0.04, 3.07]
2.1.2 Peritoneoscopic insertion	2	177	Risk Ratio (M-H, Random, 95% CI)	0.85 [0.31, 2.38]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.2 Long-term PD catheter function	1	116	Risk Ratio (M-H, Random, 95% CI)	0.59 [0.38, 0.92]
2.2.1 Peritoneoscopic insertion	1	116	Risk Ratio (M-H, Random, 95% CI)	0.59 [0.38, 0.92]
2.3 Mechanical catheter failure	2	96	Risk Ratio (M-H, Random, 95% CI)	0.29 [0.06, 1.33]
2.3.1 Percutaneous insertion	2	96	Risk Ratio (M-H, Random, 95% CI)	0.29 [0.06, 1.33]
2.4 Postoperative death	2	64	Risk Ratio (M-H, Random, 95% CI)	Not estimable
2.4.1 Percutaneous insertion	1	35	Risk Ratio (M-H, Random, 95% CI)	Not estimable
2.4.2 Peritoneoscopic insertion	1	29	Risk Ratio (M-H, Random, 95% CI)	Not estimable
2.5 Exit-site infection	3	125	Risk Ratio (M-H, Random, 95% CI)	0.21 [0.04, 1.21]
2.5.1 Percutaneous insertion	2	96	Risk Ratio (M-H, Random, 95% CI)	0.17 [0.02, 1.37]
2.5.2 Peritoneoscopic insertion	1	29	Risk Ratio (M-H, Random, 95% CI)	0.36 [0.02, 8.07]
2.6 Peritonitis	4	273	Risk Ratio (M-H, Random, 95% CI)	0.21 [0.06, 0.71]
2.6.1 Percutaneous insertion	2	96	Risk Ratio (M-H, Random, 95% CI)	Not estimable
2.6.2 Peritoneoscopic insertion	2	177	Risk Ratio (M-H, Random, 95% CI)	0.21 [0.06, 0.71]
2.7 Haemorrhage	2	96	Risk Ratio (M-H, Random, 95% CI)	0.23 [0.04, 1.31]
2.7.1 Percutaneous insertion	2	96	Risk Ratio (M-H, Random, 95% CI)	0.23 [0.04, 1.31]
2.8 PD catheter tip migration	2	90	Risk Ratio (M-H, Random, 95% CI)	0.74 [0.15, 3.73]
2.8.1 Percutaneous insertion	1	61	Risk Ratio (M-H, Random, 95% CI)	0.97 [0.15, 6.44]
2.8.2 Peritoneoscopic insertion	1	29	Risk Ratio (M-H, Random, 95% CI)	0.36 [0.02, 8.07]
2.9 Dialysate leakage	4	273	Risk Ratio (M-H, Random, 95% CI)	0.23 [0.05, 0.95]
2.9.1 Percutaneous insertion	2	96	Risk Ratio (M-H, Random, 95% CI)	0.97 [0.06, 14.78]
2.9.2 Peritoneoscopic insertion	2	177	Risk Ratio (M-H, Random, 95% CI)	0.13 [0.02, 0.71]
2.10 Hernia formation	2	177	Risk Ratio (M-H, Random, 95% CI)	0.47 [0.06, 3.55]
2.10.1 Peritoneoscopic insertion	2	177	Risk Ratio (M-H, Random, 95% CI)	0.47 [0.06, 3.55]

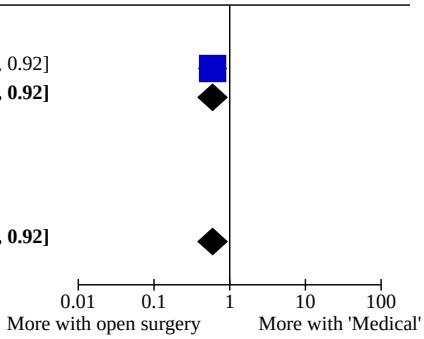
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.11 Catheter obstruction	2	177	Risk Ratio (M-H, Random, 95% CI)	0.85 [0.31, 2.38]
2.11.1 Peritoneoscopic insertion	2	177	Risk Ratio (M-H, Random, 95% CI)	0.85 [0.31, 2.38]
2.12 Omental wrapping	2	96	Risk Ratio (M-H, Random, 95% CI)	0.25 [0.06, 1.13]
2.12.1 Percutaneous insertion	2	96	Risk Ratio (M-H, Random, 95% CI)	0.25 [0.06, 1.13]

Analysis 2.1. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 1: Early PD catheter function



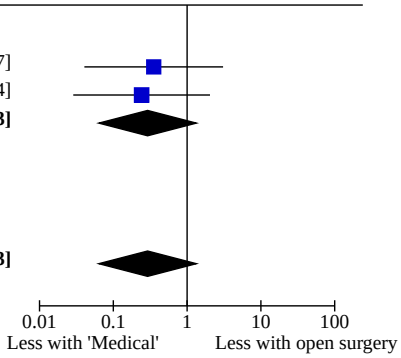
Analysis 2.2. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 2: Long-term PD catheter function

Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.2.1 Peritoneoscopic insertion						
Gadallah 1999	19	58	32	58	100.0%	0.59 [0.38 , 0.92]
Subtotal (95% CI)		**58**		**58**	**100.0%**	**0.59 [0.38 , 0.92]**
Total events:	19		32			
Heterogeneity: Not applicable						
Test for overall effect: Z = 2.35 (P = 0.02)						
Total (95% CI)		**58**		**58**	**100.0%**	**0.59 [0.38 , 0.92]**
Total events:	19		32			
Heterogeneity: Not applicable						
Test for overall effect: Z = 2.35 (P = 0.02)						
Test for subgroup differences: Not applicable						



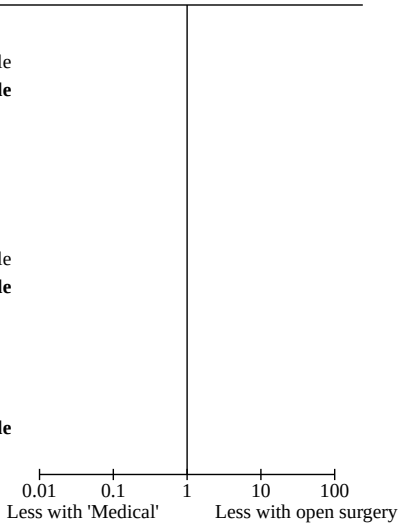
Analysis 2.3. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 3: Mechanical catheter failure

Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.3.1 Percutaneous insertion						
Merrikhi 2014	1	17	3	18	49.3%	0.35 [0.04 , 3.07]
Atapour 2011	1	31	4	30	50.7%	0.24 [0.03 , 2.04]
Subtotal (95% CI)		**48**		**48**	**100.0%**	**0.29 [0.06 , 1.33]**
Total events:	2		7			
Heterogeneity: Tau² = 0.00; Chi² = 0.06, df = 1 (P = 0.81); I² = 0%						
Test for overall effect: Z = 1.59 (P = 0.11)						
Total (95% CI)		**48**		**48**	**100.0%**	**0.29 [0.06 , 1.33]**
Total events:	2		7			
Heterogeneity: Tau² = 0.00; Chi² = 0.06, df = 1 (P = 0.81); I² = 0%						
Test for overall effect: Z = 1.59 (P = 0.11)						
Test for subgroup differences: Not applicable						



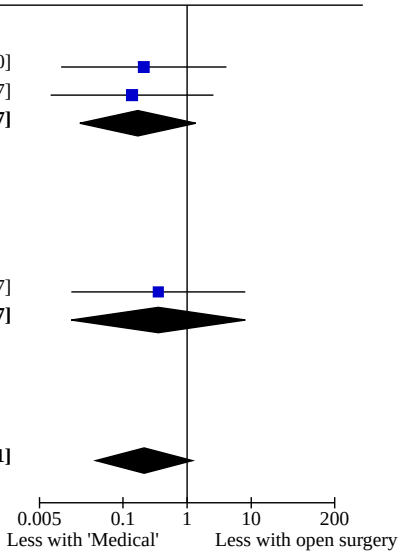
Analysis 2.4. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 4: Postoperative death

Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.4.1 Percutaneous insertion						
Merrikhi 2014	0	17	0	18		Not estimable
Subtotal (95% CI)		**17**		**18**		**Not estimable**
Total events:	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
2.4.2 Peritoneoscopic insertion						
Qian 2014	0	14	0	15		Not estimable
Subtotal (95% CI)		**14**		**15**		**Not estimable**
Total events:	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
Total (95% CI)		**31**		**33**		**Not estimable**
Total events:	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
Test for subgroup differences: Not applicable						



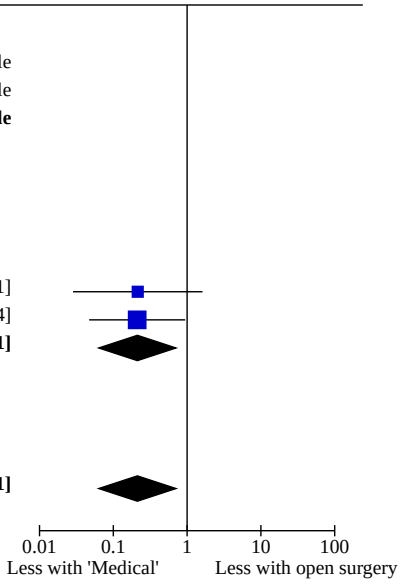
Analysis 2.5. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 5: Exit-site infection

Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.5.1 Percutaneous insertion						
Merrikhi 2014	0	17	2	18	34.1%	0.21 [0.01 , 4.10]
Atapour 2011	0	31	3	30	35.1%	0.14 [0.01 , 2.57]
Subtotal (95% CI)		**48**		**48**	**69.2%**	**0.17 [0.02 , 1.37]**
Total events:	0		5			
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.04$, df = 1 (P = 0.84); $I^2 = 0\%$						
Test for overall effect: Z = 1.67 (P = 0.10)						
2.5.2 Peritoneoscopic insertion						
Qian 2014	0	14	1	15	30.8%	0.36 [0.02 , 8.07]
Subtotal (95% CI)		**14**		**15**	**30.8%**	**0.36 [0.02 , 8.07]**
Total events:	0		1			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.65 (P = 0.52)						
Total (95% CI)		**62**		**63**	**100.0%**	**0.21 [0.04 , 1.21]**
Total events:	0		6			
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.19$, df = 2 (P = 0.91); $I^2 = 0\%$						
Test for overall effect: Z = 1.75 (P = 0.08)						
Test for subgroup differences: $Chi^2 = 0.15$, df = 1 (P = 0.70), $I^2 = 0\%$						



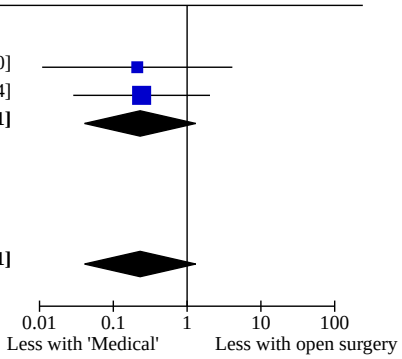
Analysis 2.6. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 6: Peritonitis

Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.6.1 Percutaneous insertion						
Atapour 2011	0	31	0	30		Not estimable
Merrikhi 2014	0	17	0	18		Not estimable
Subtotal (95% CI)		**48**		**48**		**Not estimable**
Total events:	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
2.6.2 Peritoneoscopic insertion						
Qian 2014	1	14	5	15	35.5%	0.21 [0.03 , 1.61]
Gadallah 1999	2	76	9	72	64.5%	0.21 [0.05 , 0.94]
Subtotal (95% CI)		**90**		**87**	**100.0%**	**0.21 [0.06 , 0.71]**
Total events:	3		14			
Heterogeneity: Tau² = 0.00; Chi² = 0.00, df = 1 (P = 0.99); I² = 0%						
Test for overall effect: Z = 2.53 (P = 0.01)						
Total (95% CI)		**138**		**135**	**100.0%**	**0.21 [0.06 , 0.71]**
Total events:	3		14			
Heterogeneity: Tau² = 0.00; Chi² = 0.00, df = 1 (P = 0.99); I² = 0%						
Test for overall effect: Z = 2.53 (P = 0.01)						
Test for subgroup differences: Not applicable						

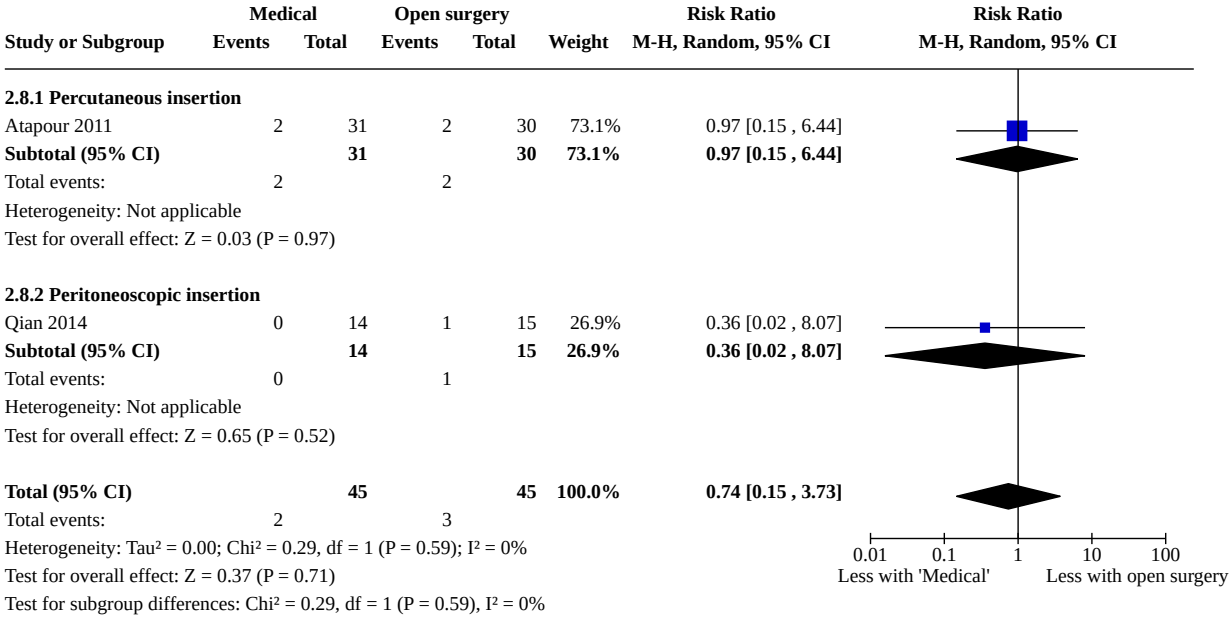


Analysis 2.7. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 7: Haemorrhage

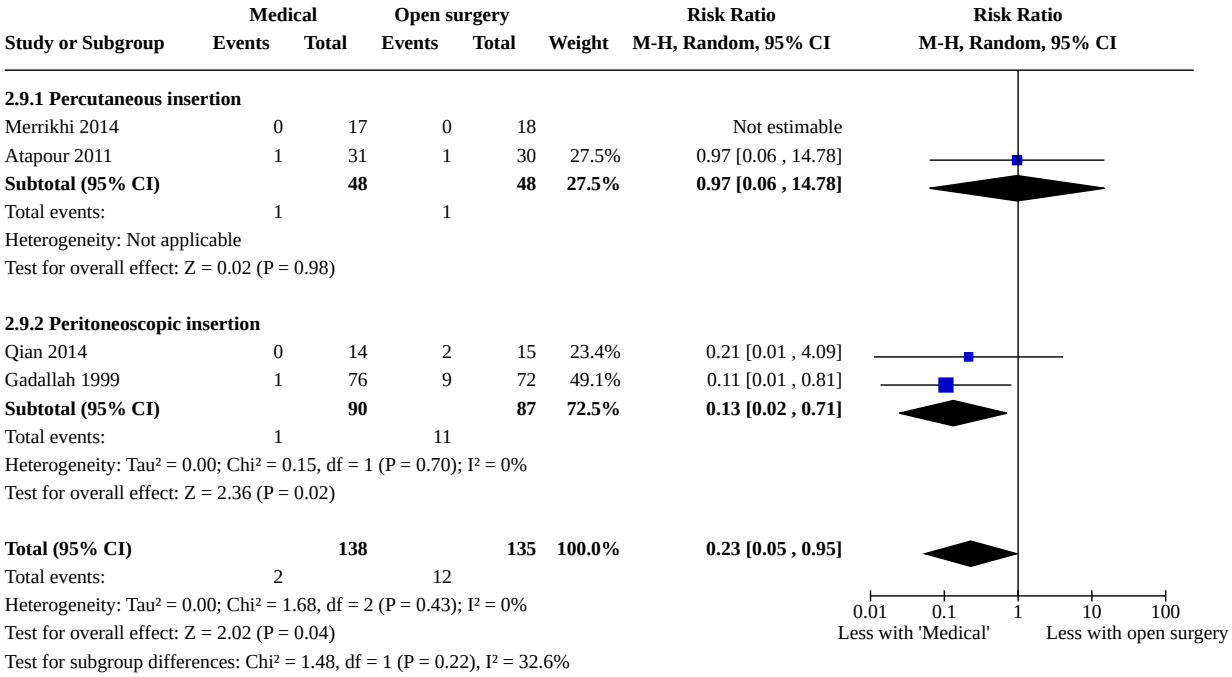
Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.7.1 Percutaneous insertion						
Merrikhi 2014	0	17	2	18	34.1%	0.21 [0.01 , 4.10]
Atapour 2011	1	31	4	30	65.9%	0.24 [0.03 , 2.04]
Subtotal (95% CI)		**48**		**48**	**100.0%**	**0.23 [0.04 , 1.31]**
Total events:	1		6			
Heterogeneity: Tau² = 0.00; Chi² = 0.01, df = 1 (P = 0.94); I² = 0%						
Test for overall effect: Z = 1.66 (P = 0.10)						
Total (95% CI)		**48**		**48**	**100.0%**	**0.23 [0.04 , 1.31]**
Total events:	1		6			
Heterogeneity: Tau² = 0.00; Chi² = 0.01, df = 1 (P = 0.94); I² = 0%						
Test for overall effect: Z = 1.66 (P = 0.10)						
Test for subgroup differences: Not applicable						



Analysis 2.8. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 8: PD catheter tip migration

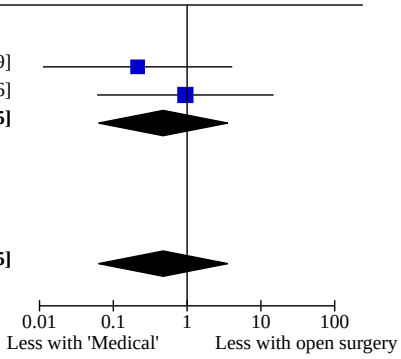


Analysis 2.9. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 9: Dialysate leakage



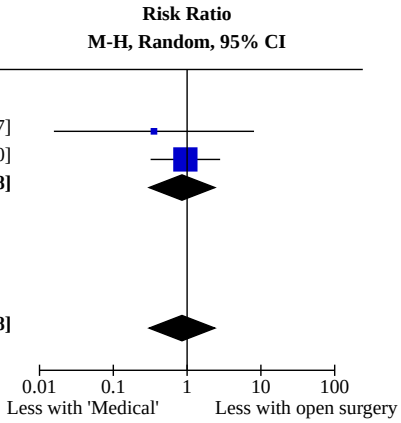
Analysis 2.10. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 10: Hernia formation

Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.10.1 Peritoneoscopic insertion						
Qian 2014	0	14	2	15	46.5%	0.21 [0.01 , 4.09]
Gadallah 1999	1	76	1	72	53.5%	0.95 [0.06 , 14.86]
Subtotal (95% CI)		**90**		**87**	**100.0%**	**0.47 [0.06 , 3.55]**
Total events:	1		3			
Heterogeneity: Tau² = 0.00; Chi² = 0.53, df = 1 (P = 0.47); I² = 0%						
Test for overall effect: Z = 0.73 (P = 0.47)						
Total (95% CI)		**90**		**87**	**100.0%**	**0.47 [0.06 , 3.55]**
Total events:	1		3			
Heterogeneity: Tau² = 0.00; Chi² = 0.53, df = 1 (P = 0.47); I² = 0%						
Test for overall effect: Z = 0.73 (P = 0.47)						
Test for subgroup differences: Not applicable						



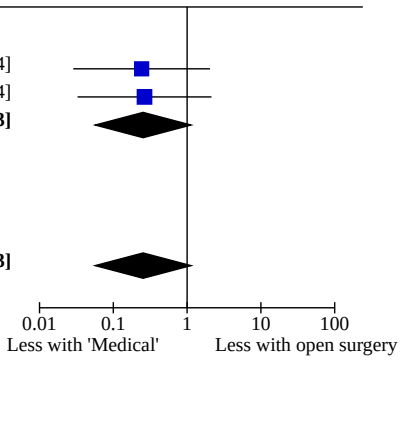
Analysis 2.11. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 11: Catheter obstruction

Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.11.1 Peritoneoscopic insertion						
Qian 2014	0	14	1	15	10.8%	0.36 [0.02 , 8.07]
Gadallah 1999	6	76	6	72	89.2%	0.95 [0.32 , 2.80]
Subtotal (95% CI)		**90**		**87**	**100.0%**	**0.85 [0.31 , 2.38]**
Total events:	6		7			
Heterogeneity: Tau² = 0.00; Chi² = 0.34, df = 1 (P = 0.56); I² = 0%						
Test for overall effect: Z = 0.31 (P = 0.76)						
Total (95% CI)		**90**		**87**	**100.0%**	**0.85 [0.31 , 2.38]**
Total events:	6		7			
Heterogeneity: Tau² = 0.00; Chi² = 0.34, df = 1 (P = 0.56); I² = 0%						
Test for overall effect: Z = 0.31 (P = 0.76)						
Test for subgroup differences: Not applicable						



Analysis 2.12. Comparison 2: Medical versus open surgical PD catheter insertion, Outcome 12: Omental wrapping

Study or Subgroup	Medical Events	Medical Total	Open surgery Events	Open surgery Total	Weight	Risk Ratio M-H, Random, 95% CI
2.12.1 Percutaneous insertion						
Atapour 2011	1	31	4	30	48.9%	0.24 [0.03 , 2.04]
Merrikhi 2014	1	17	4	18	51.1%	0.26 [0.03 , 2.14]
Subtotal (95% CI)		**48**		**48**	**100.0%**	**0.25 [0.06 , 1.13]**
Total events:	2		8			
Heterogeneity: Tau² = 0.00; Chi² = 0.00, df = 1 (P = 0.95); I² = 0%						
Test for overall effect: Z = 1.80 (P = 0.07)						
Total (95% CI)		**48**		**48**	**100.0%**	**0.25 [0.06 , 1.13]**
Total events:	2		8			
Heterogeneity: Tau² = 0.00; Chi² = 0.00, df = 1 (P = 0.95); I² = 0%						
Test for overall effect: Z = 1.80 (P = 0.07)						
Test for subgroup differences: Not applicable						



APPENDICES

Appendix 1. Electronic search strategies

Database	Search terms
CENTRAL	1. MeSH descriptor: [Renal Replacement Therapy] this term only 2. MeSH descriptor: [Peritoneal Dialysis] explode all trees 3. peritoneal dialysis:ti,ab,kw (Word variations have been searched) 4. PD or CAPD or CCPD or APD:ti,ab,kw (Word variations have been searched) 5. {or #1-#4} 6. MeSH descriptor: [Catheters, Indwelling] this term only 7. MeSH descriptor: [Catheters] this term only 8. MeSH descriptor: [Catheterization] this term only 9. catheter insert* or catheter implant*:ti,ab,kw (Word variations have been searched) 10. (peritoneal dialysis or PD) and catheter*:ti,ab,kw (Word variations have been searched) 11. "blind percutaneous" or peritoneoscopic or fluoroscopic or laparoscopic:ti,ab,kw (Word variations have been searched) 12. MeSH descriptor: [Fluoroscopy] this term only 13. MeSH descriptor: [Laparoscopy] explode all trees 14. {or #6-#13} 15. {and #5, #14}
MEDLINE	1. Renal Replacement Therapy/ 2. exp Peritoneal Dialysis/ 3. peritoneal dialysis.tw. 4. (PD or CAPD or CCPD or APD).tw. 5. or/1-4 6. Catheters, Indwelling/ 7. Catheters/ 8. Catheterization/ 9. (catheter insertion or catheter implant$).tw. 10. ((peritoneal dialysis or PD) and catheter$).tw. 11. (blind percutaneous or peritoneoscopic or fluoroscopic or laparoscopic).tw. 12. Fluoroscopy/ 13. Laparoscopy/ 14. or/6-13 15. and/5,14
EMBASE	1. Peritoneal Dialysis/ 2. Continuous Ambulatory Peritoneal Dialysis/ 3. peritoneal dialysis.tw. 4. (PD or CAPD or CCPD or APD).tw. 5. renal replacement therapy-dependent renal disease/ 6. or/1-5 7. peritoneal dialysis catheter/ 8. catheterization/ 9. peritoneal dialysis catheter$.tw. 10. (catheter insertion or catheter implant$).tw. 11. ((peritoneal dialysis or PD) and catheter$).tw. 12. (blind percutaneous or peritoneoscopic or fluoroscopic or laparoscopic).tw.

(Continued)

13.fluoroscopy/
14.laparoscopy/
15.or/7-14
16.and/6,15

Appendix 2. Risk of bias assessment tool

Potential source of bias	Assessment criteria
Random sequence generation Selection bias (biased allocation to interventions) due to inadequate generation of a randomised sequence	*Low risk of bias:* Random number table; computer random number generator; coin tossing; shuffling cards or envelopes; throwing dice; drawing of lots; minimisation (minimisation may be implemented without a random element, and this is considered to be equivalent to being random).
	High risk of bias: Sequence generated by odd or even date of birth; date (or day) of admission; sequence generated by hospital or clinic record number; allocation by judgement of the clinician; by preference of the participant; based on the results of a laboratory test or a series of tests; by availability of the intervention.
	Unclear: Insufficient information about the sequence generation process to permit judgement.
Allocation concealment Selection bias (biased allocation to interventions) due to inadequate concealment of allocations prior to assignment	*Low risk of bias:* Randomisation method described that would not allow investigator/participant to know or influence intervention group before eligible participant entered in the study (e.g. central allocation, including telephone, web-based, and pharmacy-controlled, randomisation; sequentially numbered drug containers of identical appearance; sequentially numbered, opaque, sealed envelopes).
	High risk of bias: Using an open random allocation schedule (e.g. a list of random numbers); assignment envelopes were used without appropriate safeguards (e.g. if envelopes were unsealed or non-opaque or not sequentially numbered); alternation or rotation; date of birth; case record number; any other explicitly unconcealed procedure.
	Unclear: Randomisation stated but no information on method used is available.
Blinding of participants and personnel Performance bias due to knowledge of the allocated interventions by participants and personnel during the study	*Low risk of bias*: No blinding or incomplete blinding, but the review authors judge that the outcome is not likely to be influenced by lack of blinding; blinding of participants and key study personnel ensured, and unlikely that the blinding could have been broken.
	High risk of bias: No blinding or incomplete blinding, and the outcome is likely to be influenced by lack of blinding; blinding of key study participants and personnel attempted, but likely that the blinding could have been broken, and the outcome is likely to be influenced by lack of blinding.
	Unclear: Insufficient information to permit judgement
Blinding of outcome assessment Detection bias due to knowledge of the allocated interventions by outcome assessors.	*Low risk of bias:* No blinding of outcome assessment, but the review authors judge that the outcome measurement is not likely to be influenced by lack of blinding; blinding of outcome assessment ensured, and unlikely that the blinding could have been broken.
	High risk of bias: No blinding of outcome assessment, and the outcome measurement is likely to be influenced by lack of blinding; blinding of outcome assessment, but likely that the blinding could have been broken, and the outcome measurement is likely to be influenced by lack of blinding.
	Unclear: Insufficient information to permit judgement

(Continued)

Incomplete outcome data Attrition bias due to amount, nature or handling of incomplete outcome data.	*Low risk of bias:* No missing outcome data; reasons for missing outcome data unlikely to be related to true outcome (for survival data, censoring unlikely to be introducing bias); missing outcome data balanced in numbers across intervention groups, with similar reasons for missing data across groups; for dichotomous outcome data, the proportion of missing outcomes compared with observed event risk not enough to have a clinically relevant impact on the intervention effect estimate; for continuous outcome data, plausible effect size (difference in means or standardised difference in means) among missing outcomes not enough to have a clinically relevant impact on observed effect size; missing data have been imputed using appropriate methods.
	High risk of bias: Reason for missing outcome data likely to be related to true outcome, with either imbalance in numbers or reasons for missing data across intervention groups; for dichotomous outcome data, the proportion of missing outcomes compared with observed event risk enough to induce clinically relevant bias in intervention effect estimate; for continuous outcome data, plausible effect size (difference in means or standardized difference in means) among missing outcomes enough to induce clinically relevant bias in observed effect size; 'as-treated' analysis done with substantial departure of the intervention received from that assigned at randomisation; potentially inappropriate application of simple imputation.
	Unclear: Insufficient information to permit judgement
Selective reporting Reporting bias due to selective outcome reporting	*Low risk of bias:* The study protocol is available and all of the study's pre-specified (primary and secondary) outcomes that are of interest in the review have been reported in the pre-specified way; the study protocol is not available but it is clear that the published reports include all expected outcomes, including those that were pre-specified (convincing text of this nature may be uncommon).
	High risk of bias: Not all of the study's pre-specified primary outcomes have been reported; one or more primary outcomes is reported using measurements, analysis methods or subsets of the data (e.g. sub-scales) that were not pre-specified; one or more reported primary outcomes were not pre-specified (unless clear justification for their reporting is provided, such as an unexpected adverse effect); one or more outcomes of interest in the review are reported incompletely so that they cannot be entered in a meta-analysis; the study report fails to include results for a key outcome that would be expected to have been reported for such a study.
	Unclear: Insufficient information to permit judgement
Other bias Bias due to problems not covered elsewhere in the table	*Low risk of bias:* The study appears to be free of other sources of bias.
	High risk of bias: Had a potential source of bias related to the specific study design used; stopped early due to some data-dependent process (including a formal-stopping rule); had extreme baseline imbalance; has been claimed to have been fraudulent; had some other problem.
	Unclear: Insufficient information to assess whether an important risk of bias exists; insufficient rationale or evidence that an identified problem will introduce bias.

HISTORY

Protocol first published: Issue 1, 2017

CONTRIBUTIONS OF AUTHORS

1. Draft the protocol: VB, MW, JF, RJ, RM, MC
2. Study selection: MW, JF, VB
3. Extract data from studies: VB, MW
4. Enter data into RevMan: VB
5. Carry out the analysis: VB,
6. Interpret the analysis: VB, RJ, JF, RM, MC, MW
7. Draft the final review: VB, JF, MW, RJ, RM, MC

8. Disagreement resolution: JF, MC
9. Update the review: VB

DECLARATIONS OF INTEREST

- Victoria R Briggs: no relevant interests were disclosed
- Richard M Jacques: no relevant interests were disclosed
- James Fotheringham: Baxter Healthcare Corporation (Grant / Contract), Fresenius Medical Care Deutschland GmbH (Independent Contractor - Consultant)
- Michael Campbell: no relevant interests were disclosed
- Martin E Wilkie: Baxter Healthcare Corporation, Vifor Fresenius Medical Care Renal Pharma Ltd. (Grant / Contract)
- Ravi Maheswaran: no relevant interests were disclosed

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Internal sources

- Sheffield Kidney Institute, UK
- School of Health and Related Research, University of Sheffield, UK

External sources

- Baxter Clinical Evidence Council Grant, UK

  Baxter Clinical Evidence Council grant was awarded to Dr Victoria Briggs to undertake a period of research relating to peritoneal dialysis access practices and outcomes. The current systematic review is part of that work but the award was not specifically awarded for the purpose of its completion. The award has partially funded salary costs and attendances at conferences to highlight the work and disseminate the study plan.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

There are no significant differences to the protocol. It should be noted that the primary outcome, 'Long-term PD catheter function' could not be evaluated in any of the included studies.

INDEX TERMS

Medical Subject Headings (MeSH)

Catheters; Dialysis Solutions; *Peritoneal Dialysis; *Peritonitis; Renal Dialysis

MeSH check words

Adult; Child; Humans