Laparoscopic versus traditional peritoneal dialysis catheter insertion: a meta analysis

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Abstract

Objective: The objective of this study is to compare the catheter-related complications as well as catheter survival between laparoscopic and traditional surgery in peritoneal dialysis catheter insertion.

Results: Five randomized controlled trials and 11 cohort studies were identified. Meta-analysis showed laparoscopic catheter is superior to traditional surgery in terms of controlling catheter migration (OR 0.17, 95% CI 0.08–0.33; \( p < 0.00001 \)) and catheter survival rate (1-year survival rate: OR 3.05, 95% CI 1.72–5.41, \( p = 0.0001 \); 2-year survival rate: OR 2.07, 95% CI 1.29–3.33, \( p = 0.0001 \)), but slightly increases the risk of bleeding (OR 2.13, 95% CI 1.07–4.23, \( p = 0.03 \)). The two groups were not significantly different in other catheter-related complications. As regards the quality of the analysis, only the migration analysis ranked A-level, while the rest fell into Class B or C. The overall research quality was moderate.

Conclusion: Laparoscopic surgery is superior to traditional surgery on reducing catheter migration and prolonging catheter survival rate according to our analysis.

Keywords
Catheter survival, peritoneal dialysis, complication, laparoscopy, peritoneal dialysis catheter insertion

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Peritoneal dialysis (PD) is one of the basic renal replacement therapies. Comparing with hemodialysis, PD has more advantages in preserving residual renal function, clearing middle molecules, and reducing cardiovascular events. Peritoneal dialysis catheter is the lifeline of the patients, many patients cannot benefit from PD due to a series of catheter-related complications such as in- and outflow obstruction, leakage, and catheter migration. Studies have found that the insertion technique may influence the function of PD catheters. In clinical practice, peritoneal dialysis catheter (PDC) insertion is most commonly performed via traditional (open) or laparoscopic surgery. However, the optimal approach of PDC insertion is still under debate. Ögünç et al. reported that laparoscopic approach had an advantage in reducing peritonitis in a small observational study, while Qiao came to the opposite conclusion.

In recent years, PD has been popularized on a grand scale in China. Several centers have performed observational studies or RCTs on this topic, collecting a mass of primary data. In this article, we conducted a systematic analysis based on both English and Chinese literature to obtain a comprehensive understanding of these two insertion technique in terms of complications and catheter survival.

Materials and methods

Searching strategy

We searched Pubmed, Elsevier Sciedirect, Cochrane Library, Springer as well as CNKI by using the keywords “peritoneal dialysis”, “laparoscopic”, “laparoscopy”, “peritoneal dialysis” without language restriction. The search was performed for articles published up to 2 September 2014.

Including and excluding criteria

We included full-text articles following PICOS principle. This principle includes (1) specific patients(P) and here we chose those with end-stage renal disease (ESRD) who need dialysis treatment, (2) specific intervention(I) and we chose PDC insertion by laparoscopic surgery, (3) specific comparison(C) and we chose PDC insertion by open surgery, (4) specific outcome(O) and we chose catheter-related complications as well as catheter survival, and (5) specific types of study(S), in this article, we chose randomized controlled studies as well as observational studies for few RCTs on this subject had been published. We excluded the article if involving the same sample or not in conformity with the above principle.

Literature screening

A supervisor (Lu): Two steps were performed by two independent researchers (Qiao and Zhou), namely initial and the second screening. In step 1, researchers read the title and abstract of each searched literature to determine the
relevance. Reviews, case-reports, letters, and other types of studies were excluded during the prescreening, so were studies concerning patients without ESRD. In step 2, full-text reading was performed by the researchers and studies not up to PICOS principle were excluded. Particularly, another study by Crabtree was excluded for involving the same sample. An experienced supervisor (Lu) leads a discussion if there was controversy.

**Outcome measures**

We extracted the following information: (1) perforation; (2) bleeding; (3) peritonitis and skin or tunnel infection; (4) catheter migration; (5) catheter obstruction; (6) leakage, including early and late leakage; (7) hernia; and (8) PD catheter survival.

**Quality assessment**

Randomized controlled trials were accessed by using criteria for evaluating the risk of bias offered by Cochrane Collaboration.18 The assessing items consist of sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other potential sources of bias.

As all observational studies in the present analysis included were cohort studies, we adopted “Newcastle–Ottawa scale” (NOS) evaluation criteria for cohort studies, which comprise the study of choice (four items, four points), group comparability (one item, two points), and outcome measures (three items, three points), a total of nine points.19

**Statistical analysis**

We performed the meta-analysis by using RevMan5.3 software (Revman International, Inc., New York, NY) provided by The Cochrane Collaboration. Heterogeneity between studies was tested by $I^2$ statistics. For homogeneous studies, we adopted fixed effects model and the Mantel–Haenszel method for calculating. While for a smaller event rates, as in the comparison of the incidence of perforation and other issues, we used the Peto method. If the studies had significant heterogeneity, the random effects model and DL method were used. $p < 0.05$ was considered statistically significant. For dichotomous outcomes, we reported results as odds ratio (OR), while reporting continuous outcomes, weighted mean difference (WMD) was used. Forest maps were drawn based on the results. Finally, we assessed the quality of each conclusion by the GRADE tool (Tajima Tool Corporation, Torrance, CA). The software we used was GRADEprofiler3.6 (Tajima Tool Corporation, Torrance, CA). While grading the results, we treated the results as obtained by cohort studies for the sake of caution.

**Results**

We found 553 papers after initial search, and then after the initial and second screening, as well as group discussion, 16 papers were enrolled in the final analysis, including five randomized controlled trials and 11 cohort studies.2–17 The PRISMA flow diagram for systematic reviews is drawn in Figure 1. One publication (by Crabtree et al. 2005) was excluded for describing patients that were already reported in another paper in 2000 by the same group.

**Study quality**

Generally speaking, the randomized controlled trials were of medium quality, as shown in Figure 2.5,10,11,14,16 While by NOS evaluation criteria, the Cohort studies scored an average of 6.2 points, with a medium quality.5–4,6–9,12,13,15,17

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Figure 1. PRISMA flow diagram of the systematic literature search.

Figure 2. Risk of bias summary graph of RCT. The green symbol indicates a low level of bias, red represents a high level of bias, the risk of bias in unclear if it’s blank.
Perforation and bleeding

Perforation is defined as perforation of bowel or bladder. For perforation, a total of three researches involving 390 patients were included in the analysis.²,⁸,¹⁵ Because of the low incidence of perforation, we used the Peto method in hypothesis testing. The results indicated that there is no significant difference in the incidence of perforation (OR 0.10, 95% CI 0.01–1.14, p = 0.06). The forest plot of this analysis is shown in Figure 3.

With a total of 780 patients from six studies, our result showed there is a higher risk of bleeding in laparoscopic method than traditional surgery (OR 2.13, 95% CI 1.07–4.23, p = 0.03).⁸,⁹,¹²,¹₄,¹₅,¹⁷ The forest plot of this analysis is shown in Figure 4.

Peritonitis and tunnel or skin infections

Fourteen studies involving a total of 1144 cases of patients described the incidence of peritonitis, the result showed that laparoscopic surgery and traditional catheterization have no significant difference in the incidence of peritonitis (OR 0.80, 95% CI 0.55–1.17, p = 0.25).³–¹¹,¹₃,¹₄,¹₆,¹⁷ The forest plot of this analysis is shown in Figure 5.

The analysis for skin or tunnel infection involved a total of 614 cases reported by nine papers. The result showed that there is no statistically significant difference between the two groups (OR 0.91, 95% CI 0.55–1.52, p = 0.72).³–⁵,⁸,⁹,¹¹,¹₅–¹⁷ The forest plot of this analysis is shown in Figure 6.

Catheter migration, obstruction, and leakage

There were 985 cases and nine studies included in the analysis, the result showed that comparing with traditional surgery, laparoscopic insertion can significantly reduce the incidence of catheter migration (OR 0.17, 95% CI 0.08–0.33, p < 0.00001).³,⁷,⁹,¹₀,¹₂–¹₅,¹⁷ The forest plot of this analysis is shown in Figure 7.

Nine studies involving a total of 690 cases were included in the analysis for obstruction. The results showed that there is no significant difference between the two methods (OR 0.80, 95% CI 0.43–1.49, p = 0.48).⁴,⁷–⁹,¹₁,¹₃–¹₆ The forest plot of this analysis is shown in Figure 8.

Some papers described the incidence of early and late-period leakage. In this analysis, we combined them together. This analysis included 13 studies involving a total of 1360 cases. The results showed that there is no significant difference between laparoscopic surgery and traditional catheterization in the incidence of leakage (OR 0.98, 95% CI 0.62–1.55; p = 0.92).²,⁴,⁵,¹¹,¹₇–¹₅ The forest plot of this analysis is shown in Figure 9.

Hernia

By analyzing 526 cases described in five studies, we found that there is no significant difference between these two methods in the incidence of hernia (OR 1.77, 95% CI 0.72–4.36, p = 0.22).³,⁹,¹₃–¹⁵ The forest plot of this analysis is shown in Figure 10.

Dialysis catheter survival

A total of four studies involving 324 cases were included in the analysis, the results showed that compared with traditional surgery, laparoscopic insertion has both better catheter 1-year survival rate and 2-year survival rate (1-year survival rate: OR 3.05, 95% CI 1.72–5.41, p = 0.0001; 2-year survival rate: OR
Figure 5. Forest plot. Odds ratios of the incidence of peritonitis between laparoscopic and traditional PD catheter insertion. CI: confidence interval. Experimental: laparoscopic surgery, control: traditional surgery.

Figure 6. Forest plot. Odds ratios of the incidence of skin and tunnel infection between laparoscopic and traditional PD catheter insertion. CI: confidence interval. Experimental: laparoscopic surgery, control: traditional surgery.

Figure 7. Forest plot. Odds ratios of the incidence of migration between laparoscopic and traditional PD catheter insertion. CI: confidence interval. Experimental: laparoscopic surgery, control: traditional surgery.
2. 07, 95% CI 1.29–3.33, \( p = 0.0001 \). The forest plots of these two analyses are shown in Figures 11 and 12.

**GRADE classification**

Among all the analysis, only the migration analysis ranked A-level, while the rest fell into Class B or C. The risk of bias accounted for the most of downgrading. The summary of finding table is shown in Table 1.

**Discussion**

Our analysis revealed that laparoscopic surgery is superior to traditional surgery on reducing catheter migration and
prolonging catheter survival rate. However, we found a slight increase in the risk of bleeding in laparoscopic surgery. There is no significant difference between the two methods in other catheter-related complications.

Xie et al. first published a systematic review of this topic in 2012, concluding that the two methods had no significant difference in the incidence of catheter-related complications. However, this systematic analysis was based on fewer studies. Hagen et al. published another detailed meta-analysis in 2013 which showed that compared with traditional catheter insertion, laparoscopic catheterization can reduce the incidence of catheter migration and prolong 1-year survival but not 2-year survival, which is contrary to Xie’s conclusion. By including more studies from China, we came to the above conclusion, which is similar to Hagen’s. And to make the results more instructive, we graded each analysis by GRADEprofeler3.6 (Tajima Tool Corporation, Torrance, CA).

Perforation, defined as the perforation of bowel and bladder, is a relatively rare but serious catheter-related complication, which is mostly due to misoperation during the surgery. Other risk factors include the tension of the intestinal tract and bladder. Our analysis showed the incidence of perforation in laparoscopic group is borderline significantly different from that of the control group. Although Oğünç et al. reported additional operation during the laparoscopic surgery, such as fixation suture of the omentum (every patient) selective liver biopsy and inguinal hernioplasties, significant risk of bleeding was not observed in this study. In addition, coagulation disorders and preoperative anticoagulant drugs use may also cause bleeding. The studies included did not control these risks, which might cause bias.

In this article, we reached the conclusion that there is no significant difference in the incidence of peritonitis between the two groups. Risk factors include hypoalbuminemia, decreased resistance of the patients, and non-standard operation when infusing dialysate. Some studies showed that the kind of preoperative antibiotics prophylaxis may also influence the incidence of peritonitis. Gadallah reported that the use of preoperative single-dose i.v. vancomycin prophylaxis for permanent peritoneal dialysis catheter placement reduced the risk of postoperative peritonitis, while cefazolin did not have statistically significant difference from the control group. Among the studies included, two studies reported the use of ceftriaxone and vancomycin (in the case of cephalosporin allergy) as prophylaxis, six studies did not
Table 1. Question: should laparoscopy versus traditional surgery be used for PD catheter insertion? (Bibliography: Peritoneoscope versus open surgery for PD. Cochrane Database of Systematic Reviews [Year], Issue [Issue]).

| Quality assessment | Study event rates (%) | Summary of Findings | Anticipated absolute effects |
|--------------------|-----------------------|---------------------|-----------------------------|
|                     | With Traditional surgery | With Laparoscopy | Relative effect (95% CI) | Risk with Traditional surgery | Risk difference with Laparoscopy (95% CI) |
| Perforation | 3/176 (1.7%) | 0/214 (0%) | OR 0.1 (0.01–1.14) | Study population | 17 per 1000 (from 17 fewer to 2 more) |
|                  | Low* due to risk of bias, imprecision | | | Moderate | 16 per 1000 (from 16 fewer to 2 more) |
| Bleeding         | 13/459 (2.8%) | 18/321 (5.6%) | OR 2.13 (1.07–4.23) | Study population | 28 per 1000 (from 2 more to 81 more) |
|                  | Low* due to risk of bias, large effect | | | Moderate | 38 per 1000 (from 3 more to 105 more) |
| Peritonitis      | 78/608 (12.8%) | 64/536 (11.9%) | OR 0.8 (0.55–1.17) | Study population | 128 per 1000 (from 53 fewer to 19 more) |
|                  | Low | | | Moderate | 175 per 1000 (from 71 fewer to 24 more) |
| Skin and tunnel infection | 40/334 (12%) | 34/280 (12.1%) | OR 0.91 (0.55–1.52) | Study population | 120 per 1000 (from 50 fewer to 52 more) |
|                  | Low | | | Moderate | 100 per 1000 (from 42 fewer to 44 more) |
| Migration        | (9 studies) | (8 studies) | | | |
| Condition       | Study population | No serious risk of bias | No serious inconsistency | No serious indirectness | No serious imprecision | Undetected | Odds Ratio (OR) (95% CI) | Study population |
|-----------------|------------------|-------------------------|--------------------------|-------------------------|------------------------|------------|--------------------------|------------------|
| **Obstruction** | **690** (9 studies) | No serious risk of bias | No serious inconsistency | No serious indirectness | No serious imprecision | Undetected | 0.17 (0.08-0.33) | 124 per 1000 (from 79 fewer to 113 fewer) |
|                 |                  |                         |                          |                         |                        |            |                          | Moderate        |
|                 |                  |                         |                          |                         |                        |            |                          | 143 per 1000 (from 91 fewer to 130 fewer) |
| **Leakage**     | **1360** (13 studies) | No serious risk of bias | No serious inconsistency | No serious indirectness | No serious imprecision | Undetected | 0.98 (0.62-1.55) | 64 per 1000 (from 35 fewer to 28 more) |
|                 |                  |                         |                          |                         |                        |            |                          | Moderate        |
|                 |                  |                         |                          |                         |                        |            |                          | 44 per 1000 (from 25 fewer to 20 more) |
| **Hernia**      | **526** (5 studies) | No serious risk of bias | No serious inconsistency | No serious indirectness | No serious imprecision | Undetected | 1.77 (0.72-4.36) | 24 per 1000 (from 7 fewer to 74 more) |
|                 |                  |                         |                          |                         |                        |            |                          | Moderate        |
|                 |                  |                         |                          |                         |                        |            |                          | 25 per 1000 (from 7 fewer to 76 more) |
| **1 year survival** | **324** (4 studies) | Serious | No serious inconsistency | No serious indirectness | No serious imprecision | Undetected | 3.05 (1.72-5.41) | 646 per 1000 (from 112 more to 262 more) |
|                 |                  |                         |                          |                         |                        |            |                          | Moderate        |
|                 |                  |                         |                          |                         |                        |            |                          | 684 per 1000 (from 104 more to 237 more) |
| **2 Year survival** | **324** (4 studies) | Serious | No serious inconsistency | No serious indirectness | No serious imprecision | Undetected | 2.07 (1.29-3.33) | 202 more per 1000 (from 112 more to 262 more) |
|                 |                  |                         |                          |                         |                        |            |                          | Moderate        |
|                 |                  |                         |                          |                         |                        |            |                          | 184 more per 1000 (from 104 more to 237 more) |

(continued)
mention the use of antibiotics, 3,4,6,9,12,13 two studies reported
the use of cefazolin, 5,8 one study reported the use of cefotaxime, 7 one study reported that all patients received
2 g of vancomycin intravenously prior to surgery as
prophylaxis, 11 one study reported antibiotic prophylaxis but
did not mention the specific drug, which might cause bias.
Furthermore, the small-scale observational study by Öğünç’s
is the only one that observed a significant lower incidence in
laparoscopic surgery, the four out of 11 cases of peritonitis in
open surgery group, however, are associated with exit site
infection according to the author. 8

Skin and tunnel infection is another major complication
after PDC insertion. Leakage, poor resistance of the patients,
and non-standard dressing change are among the risk factors.
Theoretically, as the procedures of constructing subcutaneous
tunnel are similar between these two methods, there might be,
regardless of the random effects of other risk factors, a similar
incidence of skin and tunnel infection. Our analysis showed
no significant difference between the two groups and by more
detailed inspection of each study included, we found none of
them reached a significant conclusion.

PD catheter migration is a common cause of poor drainage.
The underlying mechanism is that external force from either
intestinal peristalsis or other mechanical factors pulls the PDC
out of the minor pelvis. Our analysis suggested that
laparoscopic surgery can significantly reduce the incidence
of catheter migration. Specifically, two of the nine studies
included showed significant reduction of migration in
laparoscopic groups, 12,15 and three borderline signifi-
cant. 9,10,14 The visualized process of inserting catheter into
the minor pelvis as well as suturing PD catheter to the
abdominal cavity may account for this superiority.

PD catheter obstruction resulting from omentum wrapping,
protein clots, and tubal blockage of the catheter is another
important cause of poor drainage. The study suggested the
two methods have similar catheter obstruction incidence.
Swartz et al. 23 reported a lower incidence of obstruction in
curved tube than that of straight tube and among the studies,
Gajjar 4 did not give the corresponding description, while
others used the same type of tubes between the experimental
and control groups. 7–9,11,13–16 Omentectomy may help reduce
migration, which can be performed during laparoscopic
method. 24 Only Mattioli et al. 7 reported the procedure of
omentectomy in laparoscopic group, in which the incidence of
obstruction, however, is not significantly reduced.

There is no significant difference in the incidence of
dialysate leakage between the laparoscopic and open surgery
insertion technique. Dialysate leakage occurring in 30 d after
surgery is called the early dialysate leakage, which is usually
associated with surgery, while that occurring after 30 d is
called the late dialysate leakage, which is often associated
with mechanical factors. The quality of purse-string or inner
suture influences the incidence of leakage, other factors
include coughing, obesity, diabetes, age, grand multipara,
long-time steroids usage, and recurrent catheter insertions. 25

Most leakage can be well controlled after appropriate
treatment, and refractory leakage is rare in clinical practice.

Incisional hernia is a common complication that results
from poor healing. In clinical practice, the risk factors include
infection, which is the most common, the length and location
of incision, suturing skills, drainage materials, and general conditions.26 The incidence of hernia is 5–10% in abdominal surgery, 50% of which occur 1–2 years after operation.27 In the above text, we concluded that two groups have no difference in the incidence of infection, and we also found no difference in the incidence of hernia between these two groups.

Last but not the least, we also drew another exciting conclusion that PD catheters inserted by laparoscopic surgery have a significantly higher 1- and 2-year survival rate than the open surgery group. In Xie’s analysis, catheter survival rate was not included as an outcome, and Hagen had concluded that the 2-year catheter survival was only borderline significantly different between the two groups.20,21 Hagen had included 262 patients in their analysis, while we got the above conclusion from 324 cases. Zhou’s study may partly account for the difference. Although many studies reported the 1 year and 2 year survival, only five of them were included for analysis. The rest of them described the survival data by the Kaplan–Meier curve, in which the accurate rate was hard to get. Singh et al.28 analyzed the infectious and non-infectious causes of PD catheter removal based on the data from a single center with a 3-year follow-up, among which migration account for 34.7% of all cases (8/23). We assume that laparoscopic PDC insertion improves catheter survival rate by reducing the incidence of migration significantly.

Besides the above advantages and disadvantages on complications, we also observed other superiorities of laparoscopic method such as the convenience for performing herniorrhaphy during surgery, more suitable for obese patients and those with previous abdominal surgeries, and less operating time. On the contrary, the higher cost, as well as the necessity of general anesthesia and specialized equipment of laparoscopic method, impedes its wider application.

This paper also has some limitations. As RCTs on this study were not sufficient, we included both RCTs and observational studies, which may influence the quality of our study. In addition, the average quality of including studies are medium, and according to GRADE, most of the quality of our analysis ranks B or C, the only study ranking A level was upgraded for the significant differences.

Conclusion

Laparoscopic catheter insertion is superior to traditional technique on reducing catheter migration and prolonging catheter survival rate according to our analysis, but may slightly increase the risk of bleeding. Clinicians should weigh the advantages and disadvantages before selecting the appropriate surgery approach. Specifically, the collaboration of surgeon and nephrologist is recommended for the decision of surgery approach as well as the management of PDC-related complications.

In recent years, transumbilical endoscopic surgery (TUES) has become a new hotspot in minimally invasive surgery, which may reduce surgical trauma and bring the same benefits.29 Despite the limitations of our analysis, this article provides a more concrete answer to this controversial issue. To find out the optimal surgical approach still needs larger randomized controlled trials.

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Declaration of interest

The authors report that they have no conflicts of interest.

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