Surg Endosc
DOI 10.1007/s00464-015-4297-4

Laparoscopic versus open peritoneal dialysis catheter placement

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Received: 15 February 2015 / Accepted: 29 April 2015

Abstract

Background Laparoscopy revolutionized many General Surgery procedures by decreasing hospital stay, minimizing recovery time, and reducing wound infection rates. This study evaluates the potential benefits of laparoscopic approach to peritoneal dialysis catheter (PDC) placement.

Methods The American College of Surgeons National Surgical Quality Improvement Program database was queried for laparoscopic and open PDC placement. We evaluated patient demographics, comorbidities, operative time, length of stay (LOS), and postoperative outcomes. Univariate comparison and multivariate logistic regression analysis (MVA) adjusting for confounding factors including age, body mass index (BMI), comorbidities, and preoperative conditions were performed.

Results A total of 3134 patients undergoing PDC placement were recorded in the NSQIP database between 2005 and 2012, including 2412 laparoscopic cases (LPDC) (77 %) and 722 open (OPDC). Overall, the majority of cases were performed by General Surgeons (81 %) with most of the remainder completed by Vascular Surgeons (16.8 %). Patients undergoing LPDC versus OPDC demonstrated no significant difference in gender (54 vs. 56 % males, $p = 0.4$), smoking history (8.5 ± 18.3 vs. 7.2 ± 16.9 pack years, $p = 0.06$), diabetes (42 vs. 40 %, $p = 0.4$), COPD (4.6 vs. 5 %, $p = 0.63$), or preoperative dialysis requirement (72 vs. 73 %, $p = 0.6$), but they were younger (57.2 ± 14.8 vs. 60.5 ± 15.9 years, $p = 0.05$) and had a higher BMI (29.3 vs. 29 kg/m^2, $p = 0.04$). In univariate analysis of LPDC versus OPDC, overall wound complications (1.6 vs. 2.9 %, $p = 0.02$), deep surgical site infections (0.12 vs. 0.83 %, $p < 0.006$), minor complications (3.8 vs. 6.5 %, $p < 0.05$), major complications (4.3 vs. 6.9 %, $p < 0.05$), and LOS (1.8 ± 11.9 vs. 4.4 ± 10 days, $p < 0.0001$) favored the LPDC approach, but only operative time (57.6 ± 4.6 vs. 71.8 ± 5.3, $p < 0.001$) remained significant in MVA after controlling for confounding factors. Both LPDC and OPDC had equivalently low rates of catheter failure (0.21 vs. 0.14 %, $p = 0.7$).

Conclusion Using univariate analysis, there appears to be a benefit from LPDC placement. However, after controlling for confounding variables, the techniques appear to have equal outcomes. Surgeons should perform a LPDC or OPDC according to the approach with which they are most familiar. However, continued adoption, dispersal, and refinement of the laparoscopic approach may further optimize patient outcomes.

Keywords Peritoneal dialysis · Laparoscopic · Open · Dialysis · NSQIP · Peritoneal dialysis catheter

The number of patients requiring dialysis in the USA appears to be on the rise, with 615,899 patients requiring dialysis in 2011, an increase of 3.2 % from the year preceding [1]. The overall incidence of new cases was 115,643 within that time frame, which accounted for $34.3 billion

Presented at the SAGES 2015 Annual Meeting, April 15–18, 2015, Nashville, Tennessee.

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in total Medicare costs [1]. Worldwide, approximately 197,000 patients utilize peritoneal dialysis with the majority (59 %) occurring in developing countries; the remaining 41 % take place in developed countries and 26,517 are within the USA [2]. Given the rising need for dialysis support, a study concerning peritoneal dialysis catheter (PDC) placement and a contrast in techniques might yield important information for General Surgeons.

For some time, implants such as the Tenckhoff catheter have been placed percutaneously, peritoneoscopically, open, and laparoscopically. The goal was safe and effective long-term use of the catheter with the avoidance of complications such as peritonitis and bowel perforation found in percutaneous or peritoneoscopic placement [3, 4]. Since the 1970s, failure of PDCs occurred up to 70 % of patients within the first year of placement [5–15]. Early pioneers in laparoscopy applied peritoneoscopy as visualization through the percutaneous access site for salvage procedures; over time, laparoscopic salvage techniques for nonfunctioning catheters became more refined, allowing for PDC retrieval, adhesiolysis, catheter tip fixation, as well as omental manipulation, including omentectomy as necessary [5–15]. Initial placement of PDCs laparoscopically was first described in case series in 1990s [16–23]. Notably, Crabtree et al. [24] published a series describing the feasibility and benefit of continuous visualization not available with the peritoneoscopic approach alone and with the added advantage of smaller incisions compared to the conventional open technique. Seeking a decrease in hospital stay, a reduction in recovery time, and fewer wound infections was the goal as had been seen in many other laparoscopic procedures within the realm of General Surgery [25–27]. This study evaluates national data on the potential benefits of the laparoscopic approach to PDC placement.

Methods

Study design

Data source

This study was conducted with the approval of the Carolinas Medical Center Institutional Review Board. This retrospective study examined the outcomes of PDC insertion comparing laparoscopic versus open technique evaluating data from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database. The methodology of collection within this database has been previously detailed [28, 29]. Patients were categorized based on the corresponding CPT codes for laparoscopic (49,324, introduced in 2007) and open (49,421, present in 2005) initial PDC placement, and data were collected. Additionally, concomitant procedures including omentectomy (49,255), open adhesiolysis (44,005), and laparoscopic adhesiolysis (44,180, 58,660) were captured based on CPT codes.

Data collection

Patient characteristics such as age, sex, race, body mass index (BMI), tobacco use, comorbidities, incidence of ascites, and preoperative status of dialysis were collected. Perioperative characteristics such as surgeon specialty, type of anesthesia, operative time, and length of stay (LOS) were collected. Postoperative outcomes including pneumonia, venous thromboembolic event, stroke, myocardial infarction, sepsis, acute or progressive renal failure, catheter failure, superficial surgical site infection (SSI), deep SSI, intra-abdominal SSI, return to the operating room, and 30-day mortality were included. In addition, the complications were grouped into wound-related, minor, and major overall complication classifications to allow for statistical comparison, as previously published [30].

Statistical analysis

Standard statistical analysis was performed using Pearson's Chi-square and Fisher's exact tests for categorical variables and unpaired t test or Kruskal–Wallis test for nonparametric continuous data and ordinal variables as appropriate to obtain a two-tailed p value; statistical significance was defined as $p < 0.05$. Additionally, multivariate logistic regression analysis (MVA) adjusting for confounding factors including age, BMI, comorbidities, and preoperative conditions was performed. All data were analyzed using Statistical Analysis Software, version 9.4 (SAS Institute, Inc., Cary, NC).

Results

Patient characteristics

A total of 3134 patients underwent PDC placement between 2005 and 2012 in NSQIP hospitals. Laparoscopy was utilized in 2412 cases (75 %), and 722 operations were performed open. A comparison of patient demographics and characteristics undergoing LPDC and OPDC is shown in Table 1. Patients undergoing LPDC and OPDC had a number of similar demographic and medical findings including gender (54.4 vs. 56.0 % males, $p = 0.44$), race (Caucasian 66.2 vs. 63.5 %, $p = 0.21$), diabetes (42.5 vs. 40.7 %, $p = 0.4$), chronic obstructive pulmonary disease (4.6 vs. 5 %, $p = 0.63$), congestive heart failure (3.7 vs.

Table 1 Demographics and patient characteristics

	Laparoscopic PDC ($n = 2412$)	Open PDC ($n = 722$)	p value
Age (years)	57.2 ± 14.8	60.5 ± 15.9	0.05
Gender (male)	54.4 %	56.0 %	0.44
BMI (kg/m^2)	29.3 ± 6.7	29 ± 7.6	**0.04**
Caucasian	66.2 %	63.5 %	0.21
Diabetes mellitus	42.5 %	40.7 %	0.4
Obesity	41.3 %	37.0 %	**0.04**
Tobacco use	13.6 %	17.6 %	**0.01**
COPD	4.6 %	5.0 %	0.63
CHF	3.7 %	4.6 %	0.31
Steroid use	10.5 %	10.4 %	0.96
Preoperative dialysis	71.6 %	72.6 %	0.59
Ascites	1.0 %	5.7 %	**<0.0001**
Inpatient status	18.2 %	33.2 %	**<0.0001**

Bold values indicate statistical significance ($p < 0.05$)

PDC Peritoneal dialysis catheter placement, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *CHF* congestive heart failure

4.6 %, $p = 0.31$), and preoperative dialysis requirement (71.6 vs. 72.6 %, $p = 0.59$). LPDC patients compared to those undergoing OPDC tended to be younger (57.2 ± 14.8 vs. 60.5 ± 15.9 years, $p = 0.05$), have less tobacco use within the last year (13.6 vs. 17.6 %, $p = 0.01$) but with equal pack year history (8.5 ± 18.3 vs. 7.2 ± 16.9, $p = 0.06$), have a lower rate of ascites (1 vs. 5.7 %, $p < 0.0001$), and a slightly higher average BMI (29.3 ± 6.7 vs. 29 ± 7.6 kg/m^2, $p = 0.04$).

Operative characteristics

Complete operative details for LPDC and OPDC are displayed in Table 2. Overall, more LPDC versus OPDC cases were performed by General Surgeons (85.3 vs. 66.6 %, $p < 0.0001$). The cases performed by Vascular Surgeons were more likely via an open approach than the laparoscopic technique (29.2 vs. 13.1 %, $p < 0.0001$). A higher rate of general anesthesia was used in LPDC (97.7 vs. 80.1 %, $p < 0.0001$). Concomitant adhesiolysis was performed more frequently in the LPDC group compared to the OPDC group, (4.7 vs. 1.8 %, $p < 0.001$) but less frequently for concomitant omentectomy (0.37 vs. 1.9 %, $p = <0.0001$). In univariate analysis, LPDC versus OPDC appeared to have a difference in operative times (55.9 ± 38.8 vs. 68 ± 73.1 min, $p = 0.05$), and after MVA controlling for confounding factors, a statistically significant difference was distinguished with an adjusted mean (±SE) of 57.6 ± 4.6 min in the LPDC group compared to 71.8 ± 5.3 min in the OPDC group ($p < 0.001$).

Outcomes

In univariate analysis, the average LOS was shorter in the LPDC versus OPDC (1.8 ± 11.9 vs. 4.4 ± 10 days, $p < 0.0001$), but this difference was no longer statically significant after controlling for confounding factors of age, BMI, and comorbidities on MVA with an adjusted mean (±SE) of 6.3 ± 2.2 versus 8.6 ± 2.6 days ($p = 0.29$). Both LPDC and OPDC had low rates of catheter failure with no difference between techniques identified (0.21 vs. 0.14 %, $p = 1.0$). In univariate analysis of LPDC vs. OPDC, overall wound complications (1.6 vs. 2.9 %, $p = 0.02$), minor complications (3.8 vs. 6.5 %, $p < 0.05$), and major complications (4.3 vs. 6.9 %, $p < 0.05$) favored the LPDC approach, but rate of all postoperative complications was equivalent after MVA ($p > 0.05$). In a subanalysis comparing outcomes for cases performed either by General Surgeons or Vascular Surgeons, univariate analysis demonstrated that for cases overall, increased operative time for the Vascular Surgeon cases (59.0 ± 35.5 vs. 57.1 ± 48.6 min, $p = 0.01$) was identified; laparoscopic cases alone had higher catheter failure rates for Vascular Surgeons (0.95 vs. 0.1 %, $p = 0.02$) and increased

Table 2 Operative details of peritoneal dialysis catheter placement

	Laparoscopic PDC ($n = 2412$)	Open PDC ($n = 722$)	p value
General anesthesia	97.7 %	80.1 %	0.0001
Performed by			
General Surgeon	85.3 %	66.6 %	0.0001
Vascular Surgeon	13.1 %	29.2 %	<0.0001
Adjunct procedures			
Adhesiolysis	4.7 %	1.8 %	<0.001
Omentectomy	0.37 %	1.9 %	<0.0001
Operative time (min)[a]	57.6 ± 4.6	71.8 ± 5.3	<0.001

PDC Peritoneal dialysis catheter placement

[a] Reported as adjusted mean (±standard error) from multivariate logistic regression analysis adjusting for age, body mass index, and comorbidities

operative time (60.8 ± 36.6 vs. 54.3 ± 37.4 min, $p < 0.001$), but after MVA all these outcomes were equivalent for cases performed by either surgical specialty. Details of outcomes for univariate and multivariate analyses are outlined in Tables 3 and 4, respectively. The need for return to the operating room was equivalent for LPDC and OPDC (5 vs. 6.8 %, $p = 0.07$) as well as 30-day mortality (0.9 vs. 1.7 %, $p = 0.09$).

Discussion

In this study of more than 3100 PDC patients, there was a significant decrease in operative times, LOS, overall wound-related, minor, and major complications in the laparoscopic compared to open approach to PDC placement. However, when MVA was applied to control for confounding patient factors, only operative time remained in favor of the laparoscopic approach; the techniques otherwise demonstrated equivalent outcomes.

Prior, smaller, single-center studies comparing laparoscopic and open techniques of PDC placement have, in general, favored the laparoscopic approach with exit site infection rates between 6–23.8 % compared to 8.7–47.6 % in the open cohort [31–33]. Overall, the reported rates of infection from the NSQIP data are lower in comparison with wound-related complications for both LPDC and OPDC; potentially, the infection rates are more pronounced over time as an outpatient as the catheter is used for peritoneal dialysis. Three randomized controlled trials (RCT) have been identified since 1999 looking at the comparison of laparoscopic versus open approach in PDC placement [34–37]. Earlier studies demonstrated LPDC operative times at 21.8–29 min compared to 14.3–22 min in the OPDC [36, 37]. A more recent RCT by Jwo et al. [35] had more patients than the aforementioned earlier RCTs, and operative times were comparable to our study with LPDC at 68.32 ± 31.9 min versus OPDC at 46 ± 15.99 min ($p < 0.001$). Current trends to perform laparoscopy with concomitant adhesiolysis, omentopexy, or omentectomy may be a contributing factor leading to longer operative times compared to studies published a decade ago. In this study, we wanted to examine operative times with a particular consideration of the increased frequency of adhesiolysis in the laparoscopic group, as was seen in this study. The MVA scrutinizing operative time was also designed to control for such patient factors as obesity. With this, the LPDC operations were significantly faster than the open procedures. This study did evaluate if laparoscopic omentopexy was performed in the LPDC group, which was at a rate of 7.0 %, but as no equivalent code was identified for open procedures, and, therefore, this was not used for

Table 3 Univariate comparison of surgical outcomes for peritoneal dialysis catheter placement

	Laparoscopic PDC ($n = 2412$)	Open PDC ($n = 722$)	p value
Length of stay (days)	1.8 ± 11.9	4.4 ± 10.2	**<0.0001**
Catheter failure	0.21 %	0.14 %	1.0
Overall wound complications	1.6 %	2.9 %	**0.02**
Superficial SSI	1.5 %	1.9 %	0.35
Deep incisional SSI	0.12 %	0.83 %	**0.006**
Wound disruption	0.0 %	0.14 %	0.23
Overall minor complications	3.8 %	6.5 %	**0.002**
Overall major complications	4.3 %	6.9 %	**0.004**
Organ space SSI	1.0 %	1.1 %	0.79
Acute renal failure	0.62 %	0.83 %	0.6
Progressive renal insufficiency	0.04 %	0.28 %	0.13
Pneumonia	0.6 %	1.3 %	0.09
Pulmonary embolism	0.08 %	0.14 %	0.54
Deep vein thrombosis	0.46 %	0.42 %	1.0
Myocardial infarction	0.37 %	0.28 %	1.0
Cerebrovascular accident	0.17 %	0.28 %	0.63
Sepsis	1.2 %	2.2 %	**0.04**
Septic shock	0.12 %	0.55 %	0.05
Return to the operating room	5.0 %	6.8 %	0.07
30-day mortality	0.91 %	1.7 %	0.09

Bold values indicate statistical significance ($p < 0.05$)

PDC Peritoneal dialysis catheter placement, *SSI* surgical site infection

Table 4 Multivariate regression analysis of surgical outcomes for peritoneal dialysis catheter placement adjusting for age, body mass index, and comorbidities

	Laparoscopic PDC	Open PDC OR, (95 % CI)	*p* value
Overall wound complications	1.00	1.61 (0.7–3.7)	0.27
Deep incisional SSI	1.00	2.6 (0.73–9.4)	0.14
Overall minor complications	1.00	1.4 (0.74–2.6)	0.31
Overall major complications	1.00	1.5 (0.85–2.71)	0.15
Sepsis	1.00	2.2 (0.94–5.2)	0.07
Length of stay (days)	6.3 ± 2.2	8.6 ± 2.6	0.29

Reported as adjusted mean (±standard error)

PDC Peritoneal dialysis catheter placement, *SSI* surgical site infection, *OR* odds ratio, *CI* confidence interval

comparative analysis. With respect to LOS, the previous RCTs reported a LOS ranging from 3.1 to 14.8 days in the LPDC group and 2.4–13.1 in the OPDC patients [35, 37], comparable to LOS in our study following multivariate regression analysis for these often comorbid patients.

With respect to catheter failure alone, single-center studies that follow patients up to 1 year have shown failure rates to be fairly low in the laparoscopic approach at 0–12.8 % versus 10–61.9 % for the open operations [31–33, 38, 39]. For long-term patency of catheters in patients necessitating dialysis for longer, 2-year follow-up further demonstrated lower catheter failure rates in the laparoscopic technique at 28.6 versus 76.2 % in the open approach ($p = 0.023$) [32]. Catheter failure rates for all three RCTs were reported as 0–13.5 % vs. 0–15 % in the laparoscopic and open groups, respectively [35–37]. Although our catheter failure rate was low for both LPDC versus OPDC (0.21 vs. 0.14 %, $p = 0.7$), it is likely secondary to the short-term outcomes captured by the design of the NSQIP database. However, certain adjunct techniques during laparoscopic placement currently described have shown promise in lowering the catheter failure rate to 0.5–4.6 % [22, 38]. These series identified advanced laparoscopic techniques to refine PDC placement, including rectus sheath tunneling and selective prophylactic omentopexy, which have been implemented and analyzed in a larger single series of 428 patients with a calculated 60-month catheter survival probability at 0.96 and assisted catheter survival (interval laparoscopic salvage) at 0.99 [21].

The most recent Cochrane review comparing outcomes on techniques for PDC insertion evaluated 1089 patients with 17 trials meeting inclusion criteria [40]. They found that the two approaches had no statistically significant difference in exit site infection [relative risk (RR) 0.11, 95 % confidence interval (CI) 0.01–1.92]. While they did not evaluate catheter survival specifically, any patients who were transitioned to hemodialysis or underwent transplantation were denoted as technique failure, and there was no difference between techniques (RR 0.7, CI 0.45–1.08).

Even in circumstances of prior abdominal operations with a "difficult abdomen," PDCs have been safely placed utilizing the laparoscopic approach. In our study, there was no capture of prior abdominal operations by NSQIP to identify any effect in rates of catheter failure or frequency of concomitant procedures such as adhesiolysis was associated; however, from the literature, there is evidence that PDC placement can be performed by surgeons comfortable with reoperative abdomens laparoscopically. Brandt et al. [16] first described the benefit of the laparoscopic approach in adhesiolysis and catheter placement to safely place the catheter and potentially prevent future catheter failure that may have occurred if the adhesions within the lower abdomen had remained in place. This has been further supported in recent studies confirming the safety of placement and benefit of concomitant adhesiolysis with laparoscopic PDC placement [12, 17, 41]. With respect to the cost of approaches, no difference was found in a recent meta-analysis evaluating total annual cost comparison for laparoscopically placed PDC at $69,491 compared to the open PDC placement at $69,960 [42].

Limitations

Inherent within NSQIP database analysis is the limitation of short-term follow-up. While the analysis was able to compare the rates of adhesiolysis, obesity, and other confounding operative variables, extended data involving previous surgeries and the overall frequency of concomitant procedures are not included within the database.

Future directions

In 2014, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) published guidelines on laparoscopic peritoneal dialysis access [43]. Within these guidelines, the advantages of laparoscopy to perform adhesiolysis, possible need for suture fixation of catheter tip to prevent migration, rectus sheath tunneling, omentopexy as well as omentectomy are discussed. These guidelines were further modified to detail the stepwise process of rectus sheath tunneling and explanation of obviating the need for catheter tip suturing when correct orientation of the rectus sheath tunneling is done appropriately [44]. The true benefit of this operative approach extends beyond just catheter tip visualization; laparoscopy permits adjunct procedures that may allow for longer PDC survival compared to an open approach. Further study of peritoneal catheter outcomes will be necessary as surgeons become familiar with the potential advantages provided by these updated laparoscopic techniques.

Conclusion

Open and laparoscopic techniques for PDC placement result in similar early postoperative outcomes. Surgeons should perform a LPDC or OPDC according to the approach with which they are most familiar. LPDC, however, is faster, and adhesiolysis is more frequently performed at the time of catheter insertion. Laparoscopic surgery may allow a minimally invasive approach to better direct and suture the catheter, take down adhesions, and perform an omentectomy or omental suture-pexy which may provide improved long-term catheter use not measureable in this study. On the other hand, open approach may be more suitable for those patients who are sicker and cannot tolerate laparoscopy. Continued adoption, dispersal, and refinement of the laparoscopic approach may further optimize patient outcomes.

Disclosures Drs. Heniford and Augenstein have previously been awarded surgical research and education grants and honoraria from W.L. Gore and Associates, Ethicon, Novadaq, Bard/Davol, and LifeCell Inc. Dr. Kercher has received honoraria from Bard/Davol and Ethicon. Drs. Cox, Huntington, Blair, and Tanushree Prasad have no potential conflicts or disclosures relevant to this work.

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