Original Article

Continuous Ambulatory Peritoneal Dialysis Catheter Insertion Technique: A Comparative Study of Percutaneous versus Surgical Insertion

Abstract

Continuous ambulatory peritoneal dialysis (CAPD) is a standard renal replacement therapy, but there is a lack of consensus for catheter insertion method and type of catheter used. We retrospectively analyzed 140 peritoneal dialysis catheters (PDC) inserted in 139 CAPD patients by two methods; percutaneous (Group "P," $n = 47$) and surgical mini laparotomy (Group "S," $n = 93$) technique over a 39-month period, with cumulative experience of 2415 catheter-months: 745 catheter-months for Group "P" and 1670 catheter-months for Group "S." Break-in period was shorter in Group "P" ($P = 0.002$) whereas primary nonfunction rate was comparable ($P = 0.9$). The mean catheter survival was better in Group "S" (17.95 ± 10.96 months vs. 15.85 ± 9.41 months in "P" group, $P = 0.05$) whereas the death-censored and overall catheter survival was comparable in both groups. PDC removal due to refractory peritonitis was also comparable. Mechanical complications were more in "P" group ($P = 0.049$), leading to higher catheter removal ($P = 0.033$). The peritonitis rates were higher in "P" group (1 episode per 24.8 catheter-months vs. 1 episode per 34.8 catheter-months in "S" group, $P = 0.026$) and related to a higher number of rural patients in the group ($P = 0.04$). Patient survival was comparable. There was no effect on episodes of peritonitis in those CAPD patients who had diabetic etiology or prior hemodialysis catheter-related sepsis, age, and PDC insertion method.

Keywords: *Continuous ambulatory peritoneal dialysis, patient survival, percutaneous insertion, peritoneal dialysis catheter, peritonitis rates, surgical insertion, technique survival*

P. M. Dogra, A. K. Hooda, G. Shanmugraj, S. K. Pramanik[1]

Departments of Nephrology and [1]Medicine, Command Hospital, Kolkata, West Bengal, India

Introduction

The chronic kidney disease (CKD) burden is increasing worldwide, and approximately 7% of existing patients are added yearly to renal replacement therapy (RRT).[1] Nearly 85% of dialysis centers are in a private set-up and in urban areas. The demographic data and socioeconomic profile of CKD patients in India are available with Indian CKD registry.[2] Continuous ambulatory peritoneal dialysis (CAPD) is a viable option of RRT for ESRD patients, who do not have access to hemodialysis centers due to long travelling distance. However, the long-term viability of peritoneal dialysis catheter (PDC) is always a concern. The success of PDC depends on catheter insertion technique in addition to other factors. Tenckhoff and Schechter described a very practical percutaneous method of peritoneal catheter placement in 1968, with higher risk of bowel or vessel injury, and malpositioned catheters at that time, resulting in failure rates of up to 65% at 2 years.[3] Walking in line with the higher safety of surgical PDC insertions, safety in percutaneous PDC insertions by nephrologists is now well established.[4-6] Laparoscopic PDC insertion is another safe procedure;[7-9] though its expertise is not easily available in rural India. Very few Indian studies are available comparing PDC placement using surgical and percutaneous techniques. We present a single-center retrospective analysis of percutaneous PDC insertions (Group "P") versus surgical PDC insertion (Group "S") using mini laparotomy.

Materials and Methods

We analyzed outcomes of PDC insertion techniques by two methods between January 2012 and March 2015 at a tertiary care government hospital in eastern India. Hospital Ethics Committee approved the study. Outcome was analyzed until September 2016. The inclusion criteria were ESRD patients with age >12 years who underwent PDC insertion at this center, patients with regular follow-up, and body mass index <30 kg/m^2. The

Address for correspondence:
Dr. P. M. Dogra, Department of Nephrology, 2nd Floor, MH Jalandhar, Nalwa Road, Jalandhar - 144 005, Punjab, India.
E-mail: dodgemanu@gmail.com

Access this article online
Website: www.indianjnephrol.org
DOI: 10.4103/ijn.IJN_144_17
Quick Response Code:

How to cite this article: Dogra PM, Hooda AK, Shanmugraj G, Pramanik SK. Continuous ambulatory peritoneal dialysis catheter insertion technique: A comparative study of percutaneous versus surgical insertion. Indian J Nephrol 2018;28:291-7.

exclusion criteria were obese, critically ill patients, prior abdominal surgery and/or simultaneous abdominal herniorrhaphy, recurrent CAPD peritonitis, poor follow-up, and laparoscopy-assisted PDC insertion. There was no restriction of cross over between the two groups in case of failure of one technique.

The primary outcome was primary non-functional PDC. It was defined as catheter malfunction either immediately after its insertion (during on-table flushing) or an inability to perform CAPD exchanges after break-in, thereby prompting either PDC removal or laparoscopic repositioning. The secondary outcomes were catheter survival (death-censored and overall), patient survival, catheter infection rate (exit site infection or tunnel infection, primary peritonitis rate, and secondary peritonitis rate), catheter removal, and mechanical complications (peri-catheter leak, catheter migration, flow problems, and scrotal swelling).

Catheter survival was analyzed at 1, 3, and 6 months, 1 year, and at the end of the study. Catheter survival was estimated, as "overall catheter survival" and death-censored catheter survival. In the event of death with a functioning catheter, the date of death was taken as the last follow-up. The definition of catheter loss was PDC removal due to mechanical complications or peritonitis. Causes of patient death were sudden death and death due to sepsis of any etiology. Primary peritonitis was defined as peritonitis within 1 month of PDC insertion whereas secondary peritonitis defined as peritonitis occurring beyond 1 month.

Data collation

We evaluated CAPD insertions between January 2012 and March 2015 and their follow-up until September 2016 with inclusion and exclusion criteria. The data included the personal details of the patients, date of insertion, type of procedure, type of catheter (2-cuff straight or coiled), operator (nephrologist-1 or 2 or surgeon-1), on-table flushing result, catheter position, outpatient department flushing, size of incision, break-in, mechanical complications, peritonitis episodes and duration, patient status, and catheter status. A catheter reinsertion was taken as a new case. All data were cross-checked for accuracy. The operative differences of two techniques are deliberated in Table 1.

The percutaneous placement of PDC (Group "P") was done by nephrologist by modified Seldinger technique[3] using Quinton® PDC insertion kit [Figure 1a] by standard percutaneous technique. The surgical insertion of PDC (Group "S") was done by either nephrologist or surgeon through minilaparatomy technique [Figure 1b].

Statistical analysis

The statistical method applied was Chi-square test or Fisher's exact test, for comparing two qualitative or

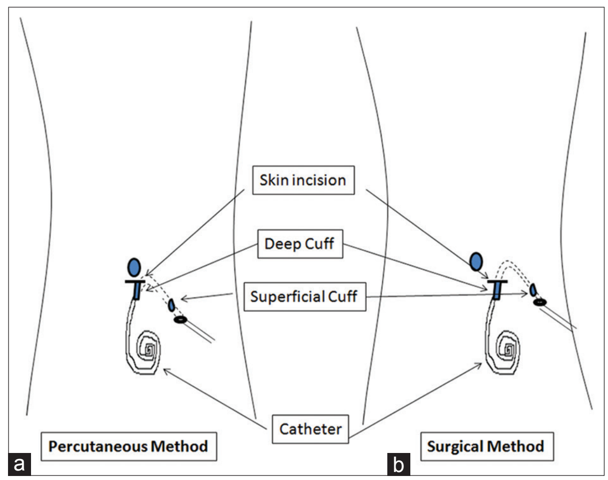

Figure 1: Schematic illustration of surgical anatomy of peritoneal dialysis catheters insertion. (a) Percutaneous technique, (b) surgical minilaparotomy technique

Table 1: Comparison of peritoneal dialysis catheters insertion procedure between percutaneous (Group "P") and surgical minilaparotomy techniques (Group "S")

Variables	Group "P"	Group "S"
Operators	Nephrologist-1	Nephrologist-2 or surgeon-1
OT assistants	1	1
Place of insertion	Bedside/minor operation theatre	Minor operation theatre
Anaesthesia	Sedation + local	Sedation + local
Skin incision location	1 cm Infraumbilical	Paramedian
Skin incision length	2-3 cm	4-5 cm
Distal cuff location	Snugly over the anterior rectus sheath	Snugly below anterior rectus sheath (by nephrologist-2) and inside posterior rectus sheath (by surgeon-1)
Instillation of cavity before catheter insertion	Yes (2 L CAPD fluid) to prevent bowel injury	No, as bowels can be visualised
Intra-operative testing of catheter function	Yes	Yes
Length and direction of tunnel	10-12 cm, caudo lateral	10-12 cm, caudo lateral
Postprocedure ambulation	24 h	24 h
Break in period in days (mean±SD)	8.06±1.24	10.07±1.71

OT: Operation theatre, CAPD: Continuous ambulatory peritoneal dialysis, SD: Standard deviation categorical variables and Student's *t*-test or Mann–Whitney test wherever applicable for continuous data. The catheter and patient survival curves plotting used Kaplan–Meier curves and compared using the Log-rank test. Censoring was also done for cases, which underwent renal transplantation during the study period. Peritonitis rates were calculated as total patient-months of follow-up divided by the total number of peritonitis episodes and expressed as episodes per patient-months. Rates were compared using two-tailed Z-tests with the assumption that there will be a probability of a given number of events occurring in a fixed time interval.

Relative risk (RR) and odds ratio (OR) were used to decipher any relation between the adverse event and the exposed group. Statistical software used in our analysis was R Development Core Team Software (R.3.3.0, Vienna, Austria).[10] The result was considered statistically significant if $P < 0.05$.

Results

One hundred and fifty-nine PDCs were inserted in the Nephrology Department of our hospital during the study period, and 140 insertions qualified for analysis [Figure 2]. Of the 140 PDC insertions, 47 PDCs were inserted by percutaneous technique (Group P) and 93 insertions were done by surgical minilaparatomy technique (Group S). The baseline characteristics of patients were comparable [Table 2]. We compared and statistically analyzed the primary and secondary outcomes between both groups [Table 3]. The success rate of PDC implantation and the immediate catheter survival was good and comparable in both groups. One PDC in each group was primarily nonfunctional ($P = 0.9$). One catheter removal occurred in "P" group within 1 month of insertion due to refractory primary peritonitis.

The catheter survival at 6 months was slightly better in "S" group (87.0% vs. 80.8%, $P = 0.05$). At the end of our study, both overall catheter survival (50.5% in "S" group and 53.1% in "P" group, $P = 0.2$) and death censored catheter survival rates were equal in both groups ($P = 0.17$) [Figure 3]. Subgroup analysis did not reveal any significant relation between catheter survival and prior hemodialysis >1 month duration (RR = 0.86, 95% confidence interval [CI] =0.53–1.39, $P = 0.55$; OR = 0.80, 95% CI = 0.39–1.65, $P = 0.55$) or with prior catheter-related bloodstream infection (CRBSI) (RR = 1.13, 95% CI = 0.69–1.85, $P = 0.6$; OR = 1.20, 95% CI = 0.56–2.58, $P = 0.62$).

Patients belonging to the different etiology subsets depicted a comparable catheter survival ($P = 0.37$) [Figure 4]. Patient survival was equal in both techniques of insertion till 24 months, but thereafter, it worsened in "S" group probably because of longer duration of patient follow-up [Figure 5]. It was comparable among the different etiological groups ($P = 0.62$),

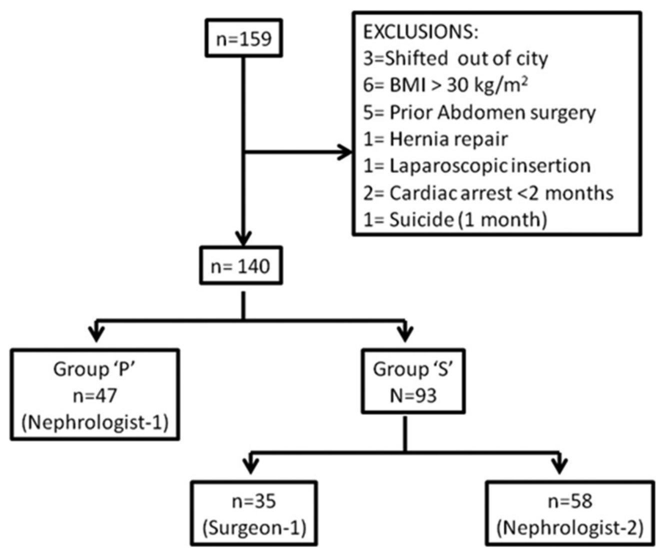

Figure 2: Details of peritoneal dialysis catheters insertions

Table 2: Baseline characteristics of patients in both groups

Variable	Sub variable	Group P (*n*=47), *n* (%)	Group S (*n*=93), *n* (%)	*P*
Age (year)		51.08±13.85	53.8±13.39	0.68
Gender	Females	16 (34)	27 (29)	0.12
Residence	Village	34 (72.3)	48 (51.6)	0.04
Urine output	<500 ml	19 (40.4)	27 (29.0)	0.88
Hypertension		32 (68.1)	71 (76.3)	0.21
Edema		28 (59.6)	54 (58)	0.63
Diabetic renal disease		17 (36.2)	26 (27.9)	0.88
Prior HD		33 (70.2)	53 (56.9)	0.09
Prior CRBSI		14 (29.8)	33 (35.4)	0.06
Hemoglobin (g/dL)		9.19±0.97	9.03±1.05	0.48
Catheter type	Straight	7 (14.8)	69 (74.1)	<0.001
	Coiled	40 (85.1)	24 (25.8)	<0.001
Preoperative antibiotics	Cephalosporin	0	63 (67.7)	
	Vancomycin + cephalosporin	47 (100)	30 (32.2)	0.02

CRBSI: Catheter-related bloodstream infection, HD: Hemodialysis, Hb: Hemoglobin

Table 3: Comparison of outcomes and other major events in peritoneal dialysis catheters insertion between Group "P" and Group "S"

Variable	Group "P" (*n*=47)	Group "S" (*n*=93)	*P*
Primary catheter non-function rate (%)	2.1	1.1	0.9
Catheter survival, *n* (%)			
1 month	45 (95.7)	92 (98.9)	0.23
3 months	45 (95.7)	92 (98.9)	0.66
6 months	38 (80.8)	81 (87)	0.05
End of study (death censored)	31 (65.9)	62 (66.3)	0.17
End of study (overall survival)	25 (53.1)	47 (50.5)	0.2
Catheter survival in months (mean±SD)	15.85±9.41	17.95±10.96	0.05
Patient survival at the end of study, *n* (%)	39 (82.9)	72 (77.4)	0.07
Deaths with functioning catheter, *n* (%)	6 (12.7)	15 (16.1)	0.06

SD: Standard deviation

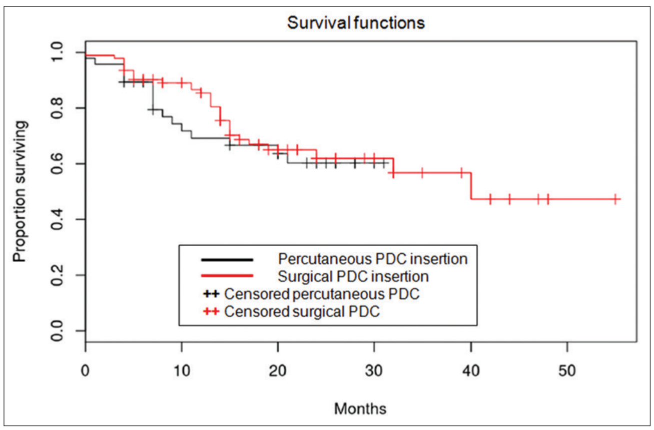

Figure 3: Kaplan–Meier curves for catheter survival in percutaneous (Group "P") and surgical minilaparotomy technique (Group "S")

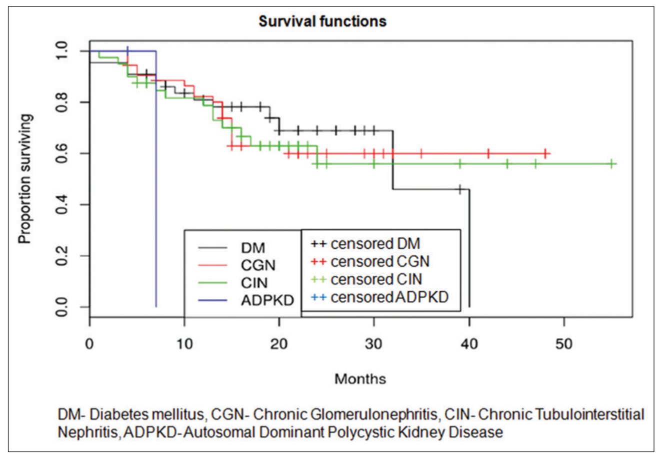

Figure 4: Kaplan–Meier curves for catheter survival in the various etiologies of end-stage renal disease

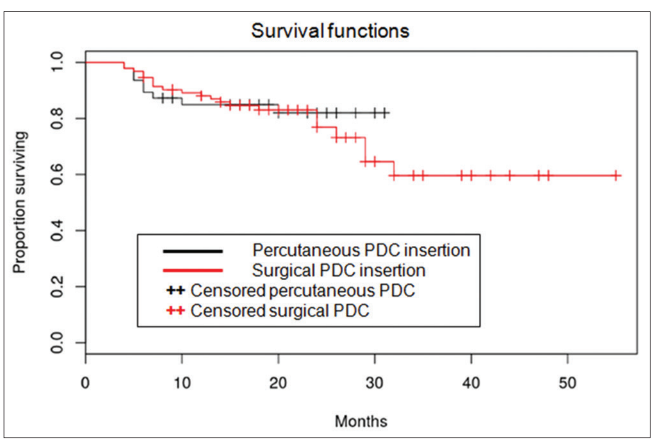

Figure 5: Kaplan–Meier curves for patient survival in percutaneous (Group "P") and surgical minilaparotomy technique (Group "S")

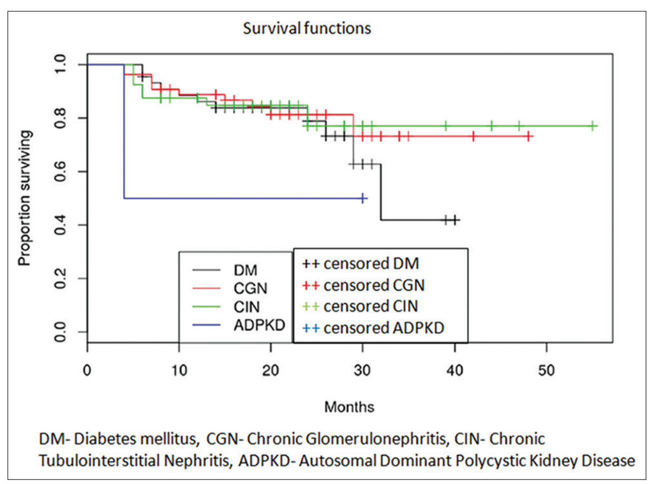

Figure 6: Kaplan–Meier curves for patient survival in the various etiologies of end-stage renal disease

though the diabetic patients' survival worsened beyond 26 months [Figure 6]. There was no relation between patient deaths to prior hemodialysis (RR = 0.76, 95% CI = 0.39–1.48, *P* = 0.42; OR = 0.71, 95% CI = 0.30–1.65, *P* = 0.4) or to those with prior CRBSI (RR = 0.58, 95% CI = 0.23–1.45, *P* = 0.24; OR = 0.52, 95% CI = 0.18–1.51, *P* = 0.23).

Mechanical complications were more in percutaneous group (*P* = 0.049) [Table 4]. Percutaneous group had more catheter removals due to migration and omental wrap (10.6%, vs. 3.2% in "S" group, *P* = 0.033), whereas catheter removal due to refractory peritonitis

Table 4: Mechanical and infectious complications in Group "P" and Group "S"

Variable	Group P (n=47)	Group S (n=93)	P
Mechanical complications (total)	9	6	0.049
Catheter migration	4	2	
Primary malfunction	1	1	
Early pericatheter leak	0	0	
Late pericatheter leak	2	0	
Incision hernia	1	0	
Scrotal swelling	0	1	
Bowel injury	0	0	
Hematoma	0	1	
Hemorrhagic outflow	1	1	
Infectious complications			
Peritonitis rates (/1000 catheter-days)	1.95	0.93	0.026
Exit site infection	1	2	0.59
Tunnel infection	0	0	
Catheter removal, n (%)			
Refractory peritonitis	11 (23.4)	21 (22.5)	0.45
Flow failure-omental wrap	1 (2.12)	1 (1.07)	0.9
Flow failure-migration	4 (8.5)	2 (2.15)	0.033
Ultrafiltration failure	1 (2.12)	2 (2.15)	
Renal transplantation	1	1	

was comparable (23.4%, vs. 22.5%, P = 0.45). The peritonitis rate was more in "P" group and was statistically significant (1 episode per 24.8 catheter-months, "P" group vs. 1 episode per 34.8 catheter-months in"S" group, P = 0.026) [Table 4]. Peritonitis rates were slightly more in rural population (P = 0.2). No relation was found between peritonitis rates and prior hemodialysis >1 month (RR = 1.25, 95% CI = 0.86–1.80, P = 0.23; OR = 1.54, 95% CI = 0.77–3.08, P = 0.22) or with prior CRBSI (RR = 1.18, 95% CI = 0.82–1.68, P = 0.36; OR = 1.38, 95% CI = 0.66–2.88, P = 0.37).

Discussion

The long-term survival of PDC has many variables, the major players being operator competence, type of catheter inserted, insertion technique, mechanical, and infective complications including peritonitis episodes. The evolution of success in PDC implantation is a continuous process, and the past five decades have seen many success stories linked to various insertion techniques.[3-6,11-17] Initiated as a domain of surgeons doing minilaparatomy PDC insertions, nephrologists gradually started with the introduction of percutaneous Seldinger technique with peel-away sheath,[3-6] only to lose the battle again to the surgeons with laparoscopic intervention,[7-9,18-21] which shortened the in-patient time and break-in period, faster recovery, less procedural morbidity, and a swift initiation of CAPD. In this study, PDCs were inserted by two methods. The basis of allocation of cases to either technique was the preference of the nephrologist.

Break-in period in our study was significantly shorter in "P" group (8.04 ± 1.17 days vs. 10.51 ± 1.71 days in "S" group, P = 0.002). This was comparable to Sivaramakrishnan *et al*. (9.7 ± 0.84 days, "P" group vs. 13.9 ± 3.39 days, "S" group),[4] whereas Sampathkumar *et al*. comparatively had much-shortened break-in period (4.6 ± 2.44 days, "P" group vs. 6.31 ± 2.68 days, "S" group).[22] Coiled two-cuff catheters had a better success rate than straight two-cuff catheters. The primary catheter nonfunction in our study was minimal (2.1% in "P" group vs. 1.1% in "S" group) as compared to other studies where it was higher.[4,5,18] The results were better as we practised the procedure of filling peritoneal cavity with CAPD fluid in "P" group[3] and an atraumatic peritoneal and omental inspection in "S" group.

Medani *et al*.[17] reported 3-month catheter survival as 86.6% versus 77.0%, P = 0.037, whereas our data showed 95.7% and 98.9%, P = 0.66, in "P" group and "S" groups, respectively. The 6-month death-censored catheter survival in our study was 80.8% and 87%. The 1-year catheter survival was better in the surgical group in our study (68.0%, "P" group vs. 76.3%, "S" group, P = 0.05). This result was also seen in studies from AIIMS, India (77.9% vs. 78.4%),[4] Park *et al*. (89.9% vs. 93.3%),[23] and Perakis *et al*. (89.5% vs. 91.1%)[24] in "P" and "S" groups, respectively. However, 1-year survival was better in percutaneous insertion as reported by Ozener *et al*. (90% vs. 82%)[5] and by Medani *et al*. in the two studies,[17,25] in "P" group and "S" groups, respectively. Meta-analysis published by Boujelbane *et al*.[26] and Tullavardhana *et al*.[27] did not show any difference in the 1-year catheter survival between both techniques. Surgical group fared better against the percutaneous group in our study compared to others wherein percutaneous insertions had better results.

The death-censored catheter survival at the end of our study was comparable in both groups, as compared to the previously reported poorer surgical outcomes.[4,5,17,26] Considering the period of follow-up, catheter survival balance was variable in both groups. Initial catheter survival (<8 months) was equal in both groups, whereas it was better in surgical group at 8–16 months period and became equal in both groups later on (>16 months). In our study, the overall catheter survival follow-up was longer in group "S" compared to group "P." This is in contrast to other observational studies where patients with percutaneous insertion had a longer catheter survival.[4,5,17,24] Catheter survival and patient survival were comparable in a subgroup of patients with diabetes, CGN, and chronic tubulointerstitial disease.

Patient survival was marginally better in "P" group beyond 24 months but statistically not significant. The cause of mortality in our patients was death at home (cause not known) (n = 18) and peritonitis-related severe sepsis (n = 4). The probable reason for death at home was a cardiovascular cause such as arrhythmias or acute coronary syndrome, and the inability to timely shift the patient to a health facility.

Studies have shown a decreasing trend in infectious complications over the years due to better hygiene, CAPD training, and follow-up. Our center had more peritonitis rates in rural population and less literate patients; however, the second peritonitis episodes were less due to retraining and hygiene neoawareness after the first peritonitis episode, thus a better catheter survival later. The catheter removal due to refractory peritonitis was more in the monsoon months (July–August) every year. The peritonitis rates in our study were comparable with others[4,5,17,26,27] though better in "S" group. The overall infectious complications were less with percutaneous insertions as seen in meta-analysis with 13 studies and 2481 patients (P = 0.02)[26] and by Tullavardhana *et al*.[27] with seven studies and 996 patients (P = 0.003) though these studies showed significant heterogeneity across studies. The authors submit that incidence of peritonitis is entirely a function of the degree of CAPD training, literacy, and personal hygiene; hence, adjudging their relation to insertion techniques is not justifiable.

Mechanical complications were comparably minimal at our center and better than pre-2010 era.[5,17,22,28] Meta-analysis[26,27] showed a lower incidence of overall mechanical complications in "P" group. Park *et al*.[23] revealed that percutaneous group had a higher incidence of early mechanical complications (11.2% vs. 0%, P = 0.002) and higher number of catheter removals due to mechanical complications (7.9% vs. 1.3%, P = 0.047), which was consistent with our results where "P" group had more mechanical complications (P = 0.049) and more catheter removal (P = 0.033). The reason for this is probably the direct visualization of falling back of omentum and bowels, and under vision guidance of catheter to its position in the surgical group. We did not have any bowel injury in our patients because of the protocols and the practice of prior filling of the peritoneal cavity in "P" group. In the surgical group, we prevented bowel injury by a diligent peritoneal entry by the prior lifting of posterior rectus sheath and peritoneum by approximately 1.5 cm to drop bowels and omentum down and placing a stay suture.

There was no pericatheter leak in immediate or late postoperative period. Many studies have reported pericatheter leak rates of varying percentage and the rates being comparable between groups. "P" group had nil incidence of early leak despite using midline insertion approach compared with higher incidences at other centers, which used paramedian approach for percutaneous insertion.[4,5,17,25] The reason for nil incidence of the early leak was the avoidance of undue stretch on linea alba entry by gentle pull-peeling of peel-away sheath approximately 0.5–1.0 cm above the skin along with simultaneous firm inward push of PDC and tight purse string secure on the rectus sheath. However, two patients developed a late pericatheter leak (at 16 and 19 months after insertion), which was managed with purse string with prolene in the first and repair of a concomitant incisional hernia in the other. There was no pericatheter leak in surgical group as the anterior and posterior rectus sheath closure was watertight and adequate time for healing of peritoneum was given (late break-in) compared to other case series.

Overall, both groups had equal catheter technical survival and patient survival. The mechanical complications, peritonitis rates, and catheter removal due to migration were less in surgical group compared to percutaneous group. The limitation of this study is that it is a retrospective analysis and the patient number is less. Our study confirms that both the insertion techniques have their own pros and cons. Advantages of percutaneous insertion as analyzed by our study are shorter break-in period, less morbidity, relatively less tissue trauma, and supposedly less equipment dependence but slightly more mechanical complications and peritonitis rates. The advantages of surgical insertions using minimally invasive techniques with a small incision and better tissue retraction are lesser mechanical complications, surety of not injuring the underlying bowels, and adequate time to peritoneal healing. The success of either insertion technique depends entirely on the expertise, experience, and sensitization of the operator to the impending complications and management thereof.

Conclusions

The catheter and patient survival in the two techniques of PDC insertion are comparable. Both the techniques have their pros and cons. Both techniques are cost effective and performed either at the bedside or in operation theater with the same number of assistants, instruments, the same set of local anesthetic and analgesic agents, and catheters. Nephrology resident should get themselves trained in both the techniques.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Agarwal SK, Srivastava RK. Chronic kidney disease in India: Challenges and solutions. Nephron Clin Pract 2009;111:c197-203.
2. Rajapurkar MM, John GT, Kirpalani AL, Abraham G, Agarwal SK, Almeida AF, *et al.* What do we know about chronic kidney disease in India: First report of the Indian CKD registry. BMC Nephrol 2012;13:10.
3. Tenckhoff H, Schechter H. A bacteriologically safe peritoneal access device. Trans Am Soc Artif Intern Organs 1968;14:181-7.
4. Sivaramakrishnan R, Gupta S, Agarwal SK, Bhowmik D, Mahajan S. Comparison of outcomes between surgically placed and percutaneously placed peritoneal dialysis catheters:

A retrospective study. Indian J Nephrol 2016;26:268-74.
5. Ozener C, Bihorac A, Akoglu E. Technical survival of CAPD catheters: Comparison between percutaneous and conventional surgical placement techniques. Nephrol Dial Transplant 2001;16:1893-9.
6. Asif A, Pflederer TA, Vieira CF, Diego J, Roth D, Agarwal A, *et al.* Does catheter insertion by nephrologists improve peritoneal dialysis utilization? A multicenter analysis. Semin Dial 2005;18:157-60.
7. Kelly J, McNamara K, May S. Peritoneoscopic peritoneal dialysis catheter insertion. Nephrology (Carlton) 2003;8:315-7.
8. Keshvari A, Najafi I, Jafari-Javid M, Yunesian M, Chaman R, Taromlou MN, *et al.* Laparoscopic peritoneal dialysis catheter implantation using a Tenckhoff trocar under local anesthesia with nitrous oxide gas insufflation. Am J Surg 2009;197:8-13.
9. Attaluri V, Lebeis C, Brethauer S, Rosenblatt S. Advanced laparoscopic techniques significantly improve function of peritoneal dialysis catheters. J Am Coll Surg 2010;211:699-704.
10. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. 2016. Available from: http://www.R-project.org/. [Last accessed on 2016 Nov 15].
11. Allon M, Soucie JM, Macon EJ. Complications with permanent peritoneal dialysis catheters: Experience with 154 percutaneously placed catheters. Nephron 1988;48:8-11.
12. Weber J, Mettang T, Hübel E, Kiefer T, Kuhlmann U. Survival of 138 surgically placed straight double-cuff Tenckhoff catheters in patients on continuous ambulatory peritoneal dialysis. Perit Dial Int 1993;13:224-7.
13. Roueff S, Pagniez D, Moranne O, Roumilhac D, Talaszka A, Le Monies De Sagazan H, *et al.* Simplified percutaneous placement of peritoneal dialysis catheters: Comparison with surgical placement. Perit Dial Int 2002;22:267-9.
14. Zaman F, Pervez A, Atray NK, Murphy S, Work J, Abreo KD, *et al.* Fluoroscopy-assisted placement of peritoneal dialysis catheters by nephrologists. Semin Dial 2005;18:247-51.
15. Ogunc G. Minilaparoscopic extraperitoneal tunneling with omentopexy: A new technique for CAPD catheter placement. Perit Dial Int 2005;25:551-5.
16. Yang PJ, Lee CY, Yeh CC, Nien HC, Tsai TJ, Tsai MK, *et al.* Mini-laparotomy implantation of peritoneal dialysis catheters: Outcome and rescue. Perit Dial Int 2010;30:513-8.
17. Medani S, Shantier M, Hussein W, Wall C, Mellotte G. A comparative analysis of percutaneous and open surgical techniques for peritoneal catheter placement. Perit Dial Int 2012;32:628-35.
18. Lu CT, Watson DI, Elias TJ, Faull RJ, Clarkson AR, Bannister KM, *et al.* Laparoscopic placement of peritoneal dialysis catheters: 7 years experience. ANZ J Surg 2003;73:109-11.
19. Oğünç G, Tuncer M, Oğünç D, Yardimsever M, Ersoy F. Laparoscopic omental fixation technique versus open surgical placement of peritoneal dialysis catheters. Surg Endosc 2003;17:1749-55.
20. Schmidt SC, Pohle C, Langrehr JM, Schumacher G, Jacob D, Neuhaus P, *et al.* Laparoscopic-assisted placement of peritoneal dialysis catheters: Implantation technique and results. J Laparoendosc Adv Surg Tech A 2007;17:596-9.
21. Crabtree JH, Burchette RJ. Effective use of laparoscopy for long-term peritoneal dialysis access. Am J Surg 2009;198:135-41.
22. Sampathkumar K, Ramakrishnan M, Ajeshkumar RN, Sah AK, Ravichandran R. Percutaneous CAPD catheter insertion by nephrologist – A single centre experience over 4 years. Indian J Perit Dial 2010;18:15-8.
23. Park YS, Min SI, Kim DK, Oh KH, Min SK, Kim SM, *et al.* The outcomes of percutaneous versus open placement of peritoneal dialysis catheters. World J Surg 2014;38:1058-64.
24. Perakis KE, Stylianou KG, Kyriazis JP, Mavroeidi VN, Katsipi IG, Vardaki EA, *et al.* Long-term complication rates and survival of peritoneal dialysis catheters: The role of percutaneous versus surgical placement. Semin Dial 2009;22:569-75.
25. Medani S, Hussein W, Shantier M, Flynn R, Wall C, Mellotte G, *et al.* Comparison of percutaneous and open surgical techniques for first-time peritoneal dialysis catheter placement in the unbreached peritoneum. Perit Dial Int 2015;35:576-85.
26. Boujelbane L, Fu N, Chapla K, Melnick D, Redfield RR, Waheed S, *et al.* Percutaneous versus surgical insertion of PD catheters in dialysis patients: A meta-analysis. J Vasc Access 2015;16:498-505.
27. Tullavardhana T, Akranurakkul P, Ungkitphaiboon W, Songtish D. Surgical versus percutaneous techniques for peritoneal dialysis catheter placement: A meta-analysis of the outcomes. Ann Med Surg (Lond) 2016;10:11-8.
28. Sampathkumar K, Mahaldar AR, Sooraj YS, Ramkrishnan M, Ajeshkumar, Ravichandran R, *et al.* Percutaneous CAPD catheter insertion by a nephrologist versus surgical placement: A comparative study. Indian J Nephrol 2008;18:5-8.