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Original Article

Comparison of peritoneal dialysis catheter insertion techniques: Peritoneoscopic, radiological and laparoscopic : A single-centre study

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catheter outcomes, catheter survival, peritoneal dialysis, peritoneoscopic catheter insertion.

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SUMMARY AT A GLANCE

This retrospective study compares perioperative outcomes and peritoneal dialysis catheter survivals between three different catheter insertions techniques–peritoneoscopic, laparoscopic surgical and radiological. Nephrologist-led peritoneoscopic insertion has been demonstrated to be a safe alternative with many benefits.

ABSTRACT:

Background: **Our centre introduced peritoneoscopic insertion of peritoneal dialysis (PD) catheter by nephrologists as a new method in August 2009 for its potential benefits.**
Aim: **The aim of this study was to compare perioperative complications and catheter survival of three techniques: peritoneoscopic, surgical and radiological techniques within a single dialysis centre.**
Method: **This study used retrospective analysis of all PD catheter inserted from 1 August 2009 to 31 July 2013 within Counties Manukau DHB, Auckland, New Zealand.**
Results: **During the study period, 293 PD catheters were inserted, 84 (29%) peritoneoscopic (P), 140 (48%) surgical (S) and 69 (23%) radiological (R). Total duration of follow-up was 5848 catheter-months, with median follow-up of 17 months. There was no difference in perioperative exit-site infections and overall early infections. There was however increased overall perioperative complications in P compared with R (HR 2.08; $P < 0.05$), predominantly from catheter removal within 60 days. Although there was no difference observed in first catheter 1-year and overall survival between insertion techniques, there was poorer complication-free survival comparing P to S (HR 1.82, $P = 0.001$) but not to R. Analyses of the latter cohort of P confirmed improvement in catheter survival compared with an earlier cohort and to other insertion techniques.**
Conclusion: **Peritoneoscopic PD catheter insertion is demonstrated to be a suitable alternative technique. As with any new procedure, 'learning curve' effects and development of operator expertise need to be taken into consideration.**

Peritoneal dialysis (PD) is a widely utilized modality of renal replacement therapy with many benefits. It has been shown to have an early survival advantage over haemodialysis at dialysis initiation,[1] preservation of residual renal function,[2] maintenance of independence, improved quality of life and lower healthcare cost.[3] The success of PD is dependent on effective complication-free peritoneal catheter access and long-term technique survival. These are considered important key performance indicators and quality assurance markers for PD.[4]

Several PD catheters insertion techniques with various modifications have been used, including both open/laparoscopic surgical insertions, Seldinger technique with or without fluoroscopic guidance and peritoneoscope-guided percutaneous insertions. Each technique has its distinctive advantages and disadvantages. Published evidence comparing insertion techniques is often limited by strict patient selection criteria in randomized controlled studies, whereas confounders exist in observational studies. There is no consensus in the 'optimal' insertion technique as patient characteristics often play an important aspect in determining the choice of technique in clinical setting. Local expertise, facility and resource availability are other determinants.

Dialysis centres with access to nephrologist-inserted PD catheters have reported positive results in technique survival and an increased PD penetration.[5,6] Our centre introduced peritoneoscopic insertion of PD catheter by nephrologist in August 2009 as an alternative insertion technique to preexisting laparoscopic surgical insertions and percutaneous modified Seldinger technique under fluoroscopic guidance by interventional radiologists. This was implemented in order to alleviate resource demands on both surgical and radiological services. The main objective of this study was to demonstrate non-inferiority of peritoneoscopic insertion as a new technique by comparing perioperative outcomes and survival of PD catheters between the three techniques in a single dialysis. We propose the reporting of a single-centre experience minimizes inter-centre variation between techniques.

METHODS

Study design and study population

A retrospective observational study of PD catheter insertions was conducted during the time period from 1 August 2009 to 31 July 2013 within Counties Manukau DHB, Auckland, New Zealand.

We identified patients through electronic dialysis database within our service and included all PD catheter insertions for analysis. Follow-up of catheter outcomes was until 31 July 2014 allowing for at least 1-year survival data.

We collected key demographic and clinical variables from patients' clinical records: age, gender, body mass index (BMI), ethnicity, first or reinserted catheter and previous history of renal replacement therapy.

Interventions

All patients with PD catheter insertions received protocol-driven perioperative catheter care with bowel preparation and antibiotics prophylaxis as per International Society of Peritoneal Dialysis (ISPD) Clinical Practice Guidelines.[4] Within an hour prior to catheter insertion, 1.5 g Cefazolin or 1 g Vancomycin were administered intravenously. Standard bowel preparation regimen administered 1 day prior to procedure were two doses of oral PicoPrep®, docusate sodium with senna and Microlax® enema. All insertions were followed by standard post-operative care unless otherwise indicated, including weekly 1 L flushes until the day of PD training. There was a minimum 2 weeks rest period between catheter insertion and commencement of continuous ambulatory PD training.

During the study period, PD catheter insertions were performed by a small number of dedicated credentialed nephrologists, interventional radiologists and surgeons. This minimized the effect of inter-operator variability on outcomes. Suitability for insertion techniques were assessed by the patients' caring nephrologists.

Peritoneoscopic insertion technique

This insertion technique was first introduced in August 2009 and was initially performed by either of two nephrologists. Local anaesthetic (1% lignocaine with 1:100 000 adrenaline) was used in all cases. Most catheters inserted were Swan neck straight tip catheters. The technique used was similar to a previously described technique.[7] Points of difference were the use of a more paramedian approach and the use of ultrasound to identify the inferior epigastric artery and select the tract of trocar needle insertion. Patients with abdominal adipose thickness of over 5 cm were not considered for this technique in view of the limited length of the trocar needle.

Radiological insertion technique

Radiological insertion technique had been described elsewhere.[8] The procedures were performed by one of three credentialed specialist interventional radiologists. Standard two-cuff PD catheters with coiled tips were used for all procedures using this technique.

Laparoscopic surgical insertion technique

This insertion technique was performed by one of two credentialed surgeons using laparoscopy. This technique had been previously described.[9] All insertions were performed under general anaesthesia. All catheters inserted were standard two-cuff PD catheters with coiled tips.

Outcomes

The primary outcomes were chosen based on ISPD recommendation on monitoring and auditing of PD catheter insertion.[4,10,11] Primary outcomes measured were both 1-year and longer term catheter survival (greater than 1 year or to end of study period) and early perioperative complications: composite endpoint including early PD catheter-related infections by day 14 (exit site infections (ESI), PD catheter tunnel infections and peritonitis), PD dialysate leak within 15 days of PD training or 30 days of catheter insertion and catheter removal by day 60. Diagnosis of PD dialysate leak was computed by tomographic peritoneography.[12] These early perioperative outcomes were chosen as they were more likely to be associated with insertion techniques, whereas long-term catheter outcomes would capture PD-related complications such as peritonitis, late dialysate leak and technique failure.

Secondary outcomes were length of inpatient admission and time to initiation of PD training. We were also interested in the likelihood of a learning curve effect for peritoneoscopic insertion as a newly introduced technique. Therefore, we compared outcomes between two separate time frames based on chronological order of catheter insertions: first, cohort included catheters inserted between 1 August 2009 and 31 July 2011 and second, cohort between 1 August 2011 and 31 July 2013.

Statistical analysis

All data were analysed, and all graphics were generated, using Stata® 12.1 (StataCorp, Texas, USA).

Differences in baseline characteristics were analysed using χ^2 or Fisher's exact test for categorical variables. Kruskal–Wallis one-way analysis of variance (ANOVA) was used for continuous variables unless P values needed to be specified between each of the determining variables. In such cases, ANOVA with Bonferroni correction were used.

Outcomes were analysed and adjusted for baseline variables using logistic regression to determine odds ratios (OR) and *P* values.

For survival analyses, the Kaplan–Meier method was used, censored for death and transplantation in both catheter removal and combined analyses and similarly censored for both death, catheter removal and transplantation in infection-related outcomes. Hazard ratios (HR), 95% confidence intervals (CI) and *P* values were calculated using Cox proportional hazard analyses adjusted for baseline characteristics. Analyses were performed as outcomes at the end of study date, 31 July 2014 or at 365-day follow-up, which ever was the latter.

Statistical significance was attributed to findings if two-tailed *P* values were <0.05.

RESULTS

Baseline characteristics

In the observation period, 293 PD catheters were inserted, 84 (29%) peritoneoscopic (P), 140 (48%) surgical (S) and 69 (23%) radiological (R). The total follow-up was 5848 catheter months, and median follow-up for each catheter was 17 months (interquartile range 6.9–30 months).

Comparing baseline characteristics between the three insertion groups (Table 1), there were no statistically significant differences in patient age, gender and ethnicity. There was a significant difference in patient's BMI with those with peritoneoscopic insertion having a lower average BMI (P: 26.77 ± 4.1, S: 29.3 ± 5.8, R: 29.5 ± 5.3; $P = 0.005$) and much less, only 19%, in the obese category (BMI > 30kg/m^2). In addition, there was a much higher proportion of patients with previous history of PD in the surgical group (P: 5%, S: 38%, R: 7%; $P < 0.0005$).

Perioperative outcomes

The occurrence of ESI within 14 days were 10% (P), 16.7% (S) and 8.2% (R), with no significant differences between insertion techniques, P *versus* S HR 1.0; $P = 0.99$, P *versus* R HR 0.86; $P = 0.80$ and S *versus* R 0.87; $P = 0.79$. There were seven episodes of PD peritonitis within 14 days, two (2.4%) in P, four (2.9%) in S and one (1.4%) in R; the events were too infrequent to be analysed alone. There was also no difference in overall early infectious complications between insertion techniques. Comparing first cohort and second cohort within the peritoneoscopic insertion group, there was also no difference in perioperative infectious complications found.

There were nine perioperative leaks, five (5.9%) in P, four (2.9%) in S and none in R. There was a trend towards increasing likelihood of no-cause discriminative catheter removal within 60 days with peritoneoscopic insertions, but not achieving statistical significance, P *versus* S HR 2.0; $P = 0.15$ and P *versus* R HR 2.08; $P = 0.21$. Comparing first and second cohort peritoneoscopic insertions, there was a trend towards better outcome in the second cohort with less catheter removal (HR 0.48 (95% CI 0.12–1.86); $P = 0.287$).

Table 1 Baseline demographics and characteristics by insertion technique

	Peritoneoscopic	Surgical	Radiological	*P* value
	84 (29%)	140 (48%)	69 (23%)	
Age	57.4 ± 15	55.78 ± 13.6	55.2 ± 16.37	NS
Gender				
Male	51	71	38	NS
Female	33	69	31	
Ethnicity				
European/Other	22	34	12	NS
NZ Maori	20	44	22	
Pacific People	26	43	29	
Asian	16	19	6	
BMI	26.77 ± 4.1	29.3 ± 5.8	29.5 ± 5.3	0.005
BMI category				
<25	25 (30%)	36 (26%)	11 (17%)	<0.0005
25–30	43 (51%)	38 (27%)	26 (40%)	
>30	16 (19%)	66 (47%)	28 (43%)	
PD history				
Previous PD	4 (4.8%)	53 (38%)	5 (7.2%)	<0.0005
No Previous PD	80 (95%)	87 (62%)	64 (93%)	
Cohort				
Cohort 1	51	89	29	0.01
Cohort 2	33	51	40	
Renal transplant	4 (4.8%)	6 (4.3%)	3 (4.3%)	NS

PD, peritoneal dialysis; BMI, body mass index; NS, non-significant.

Overall, there were more combined perioperative complications (early infections, leakages and catheter removal) with peritoneoscopic insertion technique, showing a significant difference in comparison with radiological insertion (P *vs* R HR 2.08; $P < 0.05$), but not reaching statistical significance difference with surgical, P *versus* S HR 1.54; $P = 0.21$, adjusted for variables. This difference was not observed in the latter cohort suggesting less perioperative complications during this particular period (HR 1.58; $P = 0.114$).

Body mass index, age and repeat catheter insertions had not been demonstrated to significantly influence the occurrence of early infectious complications, catheter removals and overall complications.

Both peritoneoscopic and radiological insertions were less likely to require inpatient hospitalization of greater than 24 h compared with surgical insertions (P *vs* S OR 2.11; $P = 0.031$, R *vs* S OR 2.44; $P = 0.016$; P *vs* R OR 0.87; $P = 0.727$) (Fig. 1).

Following insertion, time to commencement of PD training was shorter in the peritoneoscopic group (21 ± 6.97 days) comparing with surgical (26 ± 10.0 days) and radiological (26 ± 10.3 days); $P < 0.05$ (Fig. 2).

Catheter survival

At the end of study, 142 (48%) catheters had been removed with a mean survival of 607 days (minimum 15 days and maximum 1821 days).

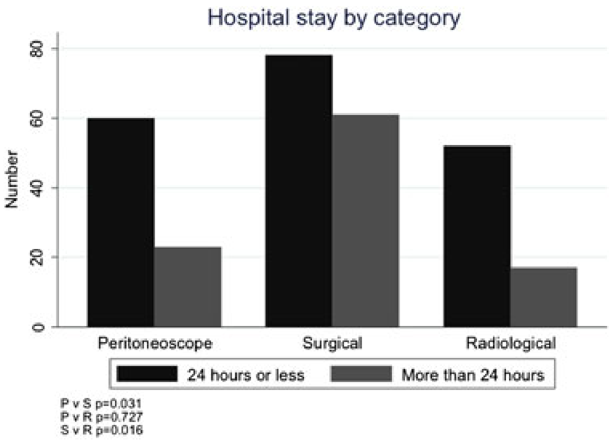

Fig. 1 Hospital days by insertion techniques.

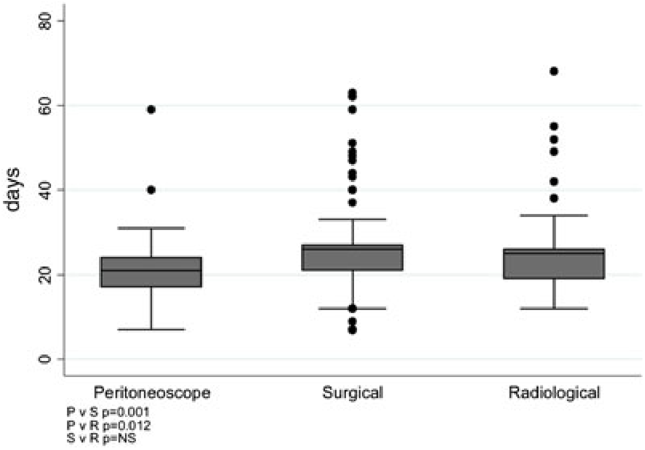

Fig. 2 Insertion to peritoneal dialysis training commencement by insertion technique.

For all catheters, 1-year survivals of 76.2% (P), 67.9% (S) and 78.26% (R) were not significantly different (P *vs* S $P = 0.850$, P *vs* R $P = 0.772$ and S *vs* R $P = 0.619$). Overall catheter survival at the end of study of 51.1% (P), 49.3% (S) and 56.5% (R) was similarly not significant (P *vs* S $P = 0.302$, P *vs* R $P = 0.454$ and S *vs* R $P = 0.864$).

Repeat catheter insertions were associated with poorer 1-year (HR 1.86 (95% CI 1.14–3.03); $P = 0.013$) and overall (HR 1.61 (95% CI 1.03–2.53); $P = 0.039$) survival compared with first catheter insertions (Fig. 3). Similarly, there was significantly poorer infection-free survival with PD catheter reinsertions compared with first catheters (HR 1.53 (95% CI 1.06–2.20); $P = 0.024$). As reinsertions were mostly surgical, survival analyses were only performed on first catheters to remove this bias.

Censoring for death and transplant, overall complication-free survival for first catheters confirmed a poorer outcome with peritoneoscopic compared with surgical insertions only (HR 1.82, 95% CI 1.27–2.62; $P = 0.001$) but not to radiological

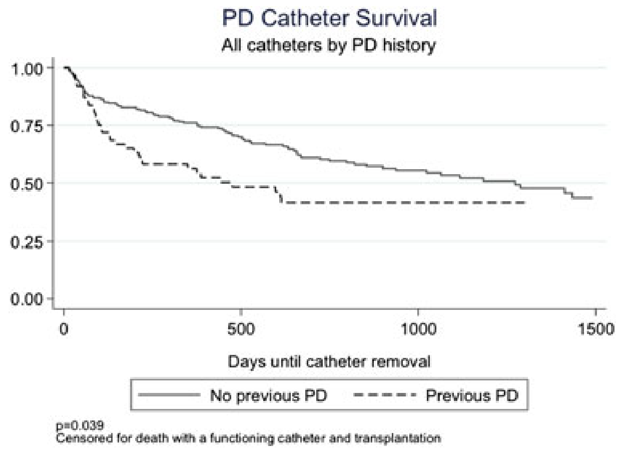

Fig. 3 Catheter survival by previous peritoneal dialysis (PD) history (first catheter *vs* repeat catheter insertion).

(Fig. 4). The difference was contributed by superior infection-related outcomes in the surgical group. There was a significantly better outcome in peritonitis-free survival with surgical insertions compared with both peritoneoscopic (HR 0.52, 95% CI 0.33–0.84; $P = 0.007$) and radiological (HR 0.57, 95% CI 0.35–0.91; $P = 0.019$). However, there was no significant difference in ESI-free survival (P *vs* S $P = 0.269$, P *vs* R $P = 0.632$ and S *vs* R $P = 0.591$). Overall infection-free survival also showed a significant difference between peritoneoscopic and surgical insertions (HR 1.6, 95% CI 1.11–2.44; $P = 0.014$). Nonetheless, overall catheter removals were not significantly different (P *vs* S $P = 0.225$, P *vs* R $P = 0.574$ and S *vs* R $P = 0.55$) (Fig. 5). First, catheter 1-year survivals were also similar, 76.2% (P), 75.9% (S) and 78.1% (R), and not significantly different (P *vs* S $P = 0.84$, P *vs* R $P = 0.82$ and S *vs* R $p = 0.96$).

Because peritoneoscopic insertions were only introduced at the start of the study period, we also compared survival outcomes for peritoneoscopic first catheter insertions in two cohorts. Second cohort peritoneoscopic insertions demonstrated

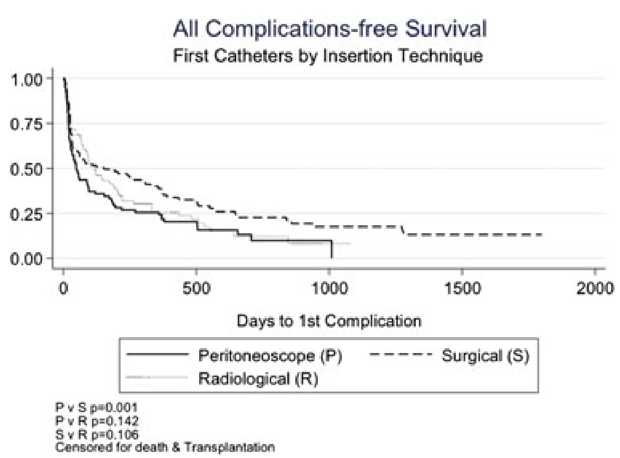

Fig. 4 First catheter complication-free survival.

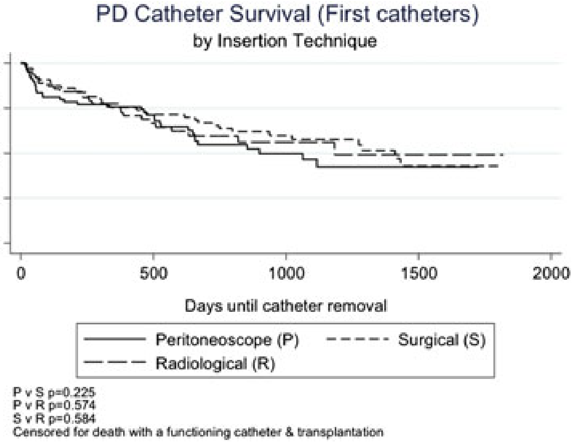

Fig. 5 First catheter overall survival by insertion technique.

superior peritonitis-free survival (HR 0.40; $P = 0.016$). In addition, there was a trend to improved 1-year catheter survival (81.82% *vs* 72.34%; $P = 0.19$) and less catheter removal (HR 0.51; $P = 0.19$).

The significant differences observed in infection-free and complication-free survival comparing peritoneoscopic insertions to other techniques were present when analysing outcomes for the earlier cohort. These differences disappeared when comparing outcomes for the latter cohort (Fig. 6).

The only potential confounding variable to show a significant difference was being of Asian ethnicity with better catheter survival compared with Europeans ($P = 0.003$) and Maori ($P = 0.006$) and PD-related infection compared with Europeans ($P = 0.005$), NZ Maori ($P = 0.009$) and Pacific People ($P = 0.019$).

DISCUSSION

Our centre has demonstrated peritoneoscopic insertion of PD catheters by nephrologists to be a safe and non-inferior alternative to established radiological and surgical insertion techniques.

Insertion techniques had not been found to influence early infectious outcomes in our study. The peritoneoscopic catheter insertions early complication rate, with peritonitis of 2.4% and dialysate leakage 5.9%, were comparable with previously reported series,[7,13,14] and the peritonitis rate achieved ISPD standard.[4] The reported early ESI within 14 days was higher than that of ISPD recommendation of <5%, which did not differ across all three insertion technique groups. Two plausible explanations were postulated. Firstly, consistent diagnosis and reporting of ESI was difficult in that clinical interpretation of ESI definition varied between treating clinicians.[15] Secondly, our centre only implemented universal exit care with topical mupirocin in April 2013, which resulted in significant improvement in exit site infection rate.[16] Although surgical technique had been shown to be superior in peritonitis-free and overall infection-free survival insertion, this was thought to be less reflective in the actual technique than early perioperative outcomes as longer-term survival can be influenced by various unadjusted confounders.

Peritoneoscopic insertions resulted in reduced hospitalization compared with surgical insertions and reduced time to commencement of PD training over other insertion techniques. Although pain score was not measured in our study, surgical insertion had previously been shown to incur higher postoperative pain.[8] The additional requirement of general anaesthesia may have resulted in patients in the surgical group to require longer inpatient admission. One of the major advantages of peritoneoscopic insertion is nephrologist-guided scheduling convenience hence allowing timely initiation and commencement of PD training rather than dependence on other services. Our centre has previously confirmed cost reduction with radiological insertion over surgical insertions.[8] We therefore extrapolated that peritoneoscopic insertions also likely to confer a similar economical advantage with reduced hospital costs because of similarity in the nature of the procedure with radiological insertion.

During the initial period (first cohort), there was increased overall perioperative complications and poorer catheter survival with peritoneoscopic insertion. In comparison, the latter cohort demonstrated improved results with comparable perioperative complication rate and longer-term catheter survival

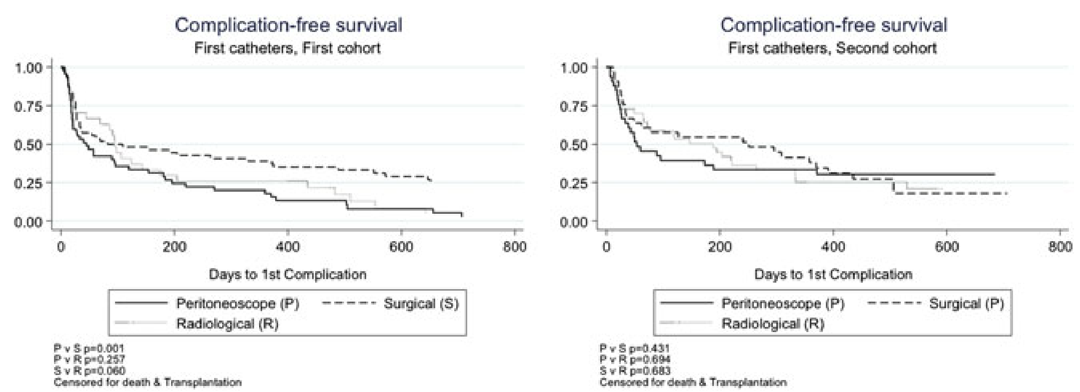

Fig. 6 First *versus* second cohort complication-free survival.

with other already established insertion techniques. This finding can be attributed to the presence of a 'learning curve' phenomenon with performance improvement following initial introductory period. Similar with other procedures, PD catheter insertion complication and success rate varies with different operators and is largely dependent on operator experience and technical expertise. In a study by Goh, using cumulative summation analysis on establishment of learning curve suggested a need of 23 procedures by a particular trainee to achieve acceptable standard.[17] It is therefore conceivable that the positive effects of peritoneoscopic catheter insertion over surgical insertion reported in other studies[7,13,14] are attenuated in our study. However, further study is needed before we can be certain of ongoing reliable standard.

Catheter tip choice was a recognized confounder in our study. Surgical and radiological insertions were exclusively coiled tip, whilst the majority of peritoneoscopic catheters were straight tip. There is evidence favouring straight tip over coiled catheter,[18–20] although this had not been demonstrated in our observational study. The size of our study may be insufficient to demonstrate straight tip benefit statistically as current evidence exists in pooled meta-analysis only.[18–20]

Patient selection bias unfortunately exists in observational studies. Patients in the surgical group tended to be obese and had previously been on PD (catheter reinsertions). This difference reflected the initial practice within our centre that nephrologists were more inclined to refer patients for laparoscopic surgical catheter insertion for its known advantages of providing good visualization of peritoneum and ability to provide surgical co-interventions at the time of catheter placement.[9,21] Then, patients with high ($>35\,kg/m^2$) BMI, especially with truncal obesity and abdominal adipose thickness of over 5 cm, were not considered for the peritoneoscopic technique because of our equipment limitations. Current available evidence had not been conclusive on whether obesity had detrimental effect on PD outcomes.[22,23] BMI has not been implicated to influence perioperative outcomes and catheter survival in our study.

We have also demonstrated significant outcome differences associated with ethnicity in our population. Asians had both infection-free and catheter survival advantages over other ethnic groups. This is consistent with published statistics from Asian countries showing longer technique survival[6,24,25] and lower peritonitis rate.[26] However, the difference observed in our study is unlikely to be attributed to variations in dialysis practice between centres and countries, which has been thought to be one of the explanations in the ethnic difference seen,[6,27,28] suggesting there are other contributing patient factors, possibly including genetics, cultural practices, adherence and socio-economics status.

In summary, our study comparing all three different PD catheter insertion techniques, within a single centre, has demonstrated that peritoneoscopic insertion is a suitable alternative technique. As previously reported, a nephrologist-led PD catheter insertion programme can increase PD penetration, with additional benefits of reduced inpatient length of stay and cost reduction. As with introduction of any new procedure or technique, consideration must be given to operator experience, centre of excellence and 'learning curve' effects.

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ETHICS

This study had been waived from ethics committee review because of the retrospective nature of the study.

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