International Urology and Nephrology (2019) 51:1867–1872
https://doi.org/10.1007/s11255-019-02177-3

NEPHROLOGY - ORIGINAL PAPER

The ideal position of the peritoneal dialysis catheter is not always ideal

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Received: 7 January 2019 / Accepted: 14 May 2019 / Published online: 1 July 2019

Abstract

Purpose Peritoneal catheter dysfunction is a frequent complication of peritoneal dialysis (PD). Traditionally, dysfunction has been attributed to catheter malposition, but whether the location of the catheter tip in the small pelvis really determines proper function is unclear.

Methods We reviewed 900 abdominal X-ray images of PD patients from a 7-year period in two PD units that use different catheter types (straight and Swan Neck Curled).

Results In 52% of the images, the dialysis catheter tip was located in the ideal position in the small pelvis and in 48% in other sites. Peritoneal catheter function was normal at the time of imaging in 87% of those with ideal catheter tip position, and in 74% of those with other than ideal position. The tip was located in small pelvis in 35% of images performed during catheter dysfunction and in 56% of those performed during normal catheter function. There were no differences between two catheter types. The positive predictive value of abdominal X-ray images to predict catheter function was 26%, and the negative predictive value 87%. We also found a significant positive correlation between polycystic kidney disease and normal catheter function. In contrast, obese patients were more likely to have catheter malfunction. Previous abdominal surgery was not associated with catheter dysfunction.

Conclusion Our data showed a higher probability of normal function of peritoneal catheters whose tips were located in the small pelvis. However, also malpositioned catheters generally functioned well, and malpositioning of the PD catheter did not in itself explain its malfunction.

Keywords Peritoneal dialysis access · Peritoneal dialysis catheter location · Catheter tip malposition · Polycystic kidney disease · Obesity

Introduction

Effective peritoneal dialysis (PD) requires a well-functioning peritoneal catheter. Peritoneal catheter dysfunction is a frequent noninfectious complication of PD and is one of the main reasons for technique failure. The incidence of dysfunction has been reported to reach 31.8% [1–4]. Several factors may contribute to catheter malfunction, including intraluminal obstruction (by fibrin strands or blood clots), extraluminal blockade (by omental wrapping or adhesions) and catheter malposition [5, 6]. Since the true pelvis is accepted as the ideal catheter tip location, positioning at other sites is defined as malposition and has been attributed a role in catheter dysfunction. Several trials have investigated various techniques of catheter insertion, including catheter tip fixation, in attempt to prevent its migration [7, 8]. In case of catheter malfunction, it is recommended to perform a plain abdominal radiography and to restore the location of the catheter if it is malpositioned. This recommendation is a reasonable conclusion from the studies that have been performed; however, most studies that reported the relation between catheter tip malposition and catheter function were based on data accessed as evaluation of catheter dysfunction, without attention to the position of normal functioning malposition catheters [9–11]. However, an instance of spontaneous relocation of a migrated peritoneal catheter has been published [12]. The few studies investigated the correlation

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of a random catheter tip position and catheter function [10, 13, 14] did not prove an effect of position on function.

Generally, dialysis patients undergo multiple X-ray examinations, related and unrelated to their dialysis program. Our observations have revealed different positions of the peritoneal catheter tip, on random X-ray examinations performed at different times for the same patient, without impact on catheter function. This led us to the aim of the current study, namely, to examine the association between random catheter tip position and catheter function in two types of catheters, and to assess other factors that may affect catheter function.

Materials and methods

The study included all patients (prevalent and incident) treated by PD between January 1, 2010 and July 31, 2016 in two dialysis units (group 1 from La Paz University Hospital, Madrid, Spain and group 2 from Carmel Medical Center, Haifa, Israel). Two types of peritoneal catheter were used: group 1 used a straight dialysis catheter and group 2 used a Swan Neck Curled catheter.

We reviewed all X-ray abdominal images [abdominal AP X-ray, computed tomography (CT), CT angiography (CTA), cystography] of patients who underwent PD during the study period at the participating medical centers, regardless of the purpose of the imaging. Patients without abdominal images during the study period were excluded from the analysis. Collected data included indications for and types of the abdominal imaging, location of the dialysis catheter, clinical records regarding catheter function, demographic characteristics, comorbidities [diabetes mellitus, polycystic kidney disease (PKD), obesity], the number of previous dialysis catheters and abdominal surgery prior to the imaging.

The location of a peritoneal catheter was defined as "ideal" if it was located in the small pelvis (below the pelvic brim) (Fig. 1) and "malpositioned" if it was in another site. Catheter function was defined as normal or dysfunctional according to the clinical records at a pre-defined time window, ranging from one week before to one week after the imaging study; while lack of records mentioning catheter dysfunction was presumed as normal functioning. Dysfunction was defined as slow drain or infusion of dialysate that affected the process of routine dialysis exchanges and that necessitated an evaluation or intervention (noninvasive such as laxatives, minimally invasive such as "alpha" maneuver, surgical interventions such as catheter replacement or repositioning, with or without omentectomy or adhesiolysis).

Statistical analysis

Statistical analysis was performed using the SPSS program. The Chi-square test of independence was performed to examine the correlation between various conditions and catheter function. Logistic regression analysis was done to evaluate the input of several variables in predicting catheter function. Sensitivity, specificity and predictive value were calculated by standard formulas.

Fig. 1 Abdominal X-ray demonstrating the "ideal" location of a peritoneal catheter located in the small pelvis (below the pelvic brim)

Results

Medical charts of 354 patients were reviewed (184 in the La Paz unit and 170 in the Carmel Medical Center unit). Data of 245 patients were available. During the study period, 900 abdominal X-ray studies were performed to these patients, including abdominal CT, CTA, abdominal plain X-ray and cystography. Only 15.4% of the images were done as evaluations of peritoneal catheter dysfunction, without a significant difference between the groups (15.4% in group 1, 15.7% in group 2). Indications for imaging studies included evaluation before kidney transplantation (abdominal CTA, cystography); evaluation of various conditions such as abdominal pain, fever, orthopedic problems of the pelvis; or as part of routine catheter post-insertion assessment. La Paz University Hospital has an active kidney transplantation program, and almost all evaluations of kidney recipients were done in the same hospital. For this reason, patients from group 1 had more abdominal images (mean 4.9 studies per patient) than patients from group 2 (mean 1.9 studies per patient).

Patients in both groups were predominantly male. The proportion of patients with diabetes was greater in group 2 than group 1 (53% vs. 24%, $p<0.05$), as was the proportion with obesity (BMI ≥ 30 kg/m^2) (30% vs. 19%, $p=0.044$) (Table 1). The prevalence of PKD was similar in the two groups—14.0% and 11.7% ($p=0.577$).

Table 1 Demographic characteristics of the patients

	I group[a] $N=142$ (%)	II group[b] $N=103$ (%)	
Male	93 (65.5%)	70 (68%)	$p=0.77$
Diabetes mellitus	34 (24%)	55 (53%)	$p<0.001$
Polycystic kidney disease	20 (14%)	12 (12%)	$p=0.58$
Obesity (BMI $\geq$ 30 kg/m^2)	27 (19%)	31 (30%)	$p=0.044$

[a]A straight dialysis catheter was used

[b]A Swan Neck Curled catheter was used

Table 2 The location of the dialysis catheter tip (by abdominal imaging) and its function

Images	I group[a] $N=696$	II group[b] $N=204$	
Function of catheter			
Normal	556 (80%)	170 (83%)	$p=0.27$
Dysfunctional	140 (20%)	34 (17%)	
Location			
Ideal (small pelvis)	366 (53%)	103 (50.5%)	$p=0.60$
Other	330 (47%)	101 (49.5%)	

[a]Group 1—La Paz University Hospital PD unit, Madrid, Spain

[b]Group 2—Carmel Medical Center PD unit, Haifa, Israel

Table 3 Correlation between the location of the catheter tip and catheter function

Images	Catheter dysfunction	Normal catheter function	Total
Catheter tip location in the small pelvis	61	408	469
Catheter tip location other than in the small pelvis	113	318	431
Total (images)	174	726	900

Although different catheters were used in groups 1 and 2 (straight and coiled types, respectively), the prevalence of catheter malposition and catheter malfunction did not differ significantly between the groups (Table 2).

Review of the abdominal studies demonstrated that in 52% of the images, the dialysis catheter tip was located in the ideal position in the small pelvis (Table 3). Among images that showed ideal catheter tip position, catheter function was normal within the time window of the imaging in 87%. Catheter dysfunction was reported in 26% of the images with a tip position that was not ideal; thus, normal function was presumed in the remaining 74%. A chi-square test of independence confirmed a significant correlation between the location of the catheter and its function ($p<0.05$). Catheters located in the small pelvis were more likely to function normally than catheters in other positions.

Table 4 Correlations of peritoneal catheter function with obesity, polycystic kidney disease (PKD), past abdominal surgery, catheter location and the number of previous catheters

Images	Dysfunction of catheter $N=174$ (100%)	Normal function of catheter $N=726$ (100%)	
Catheter location			
Small pelvis	61 (35.1%)	408 (56.2%)	$p<0.000$**
Other locations	113 (64.9%)	318 (43.8%)	
PKD			
Yes	19 (10.9%)	136 (18.7%)	$p=0.014$*
No	155 (89.1%)	590 (81.3%)	
Obesity			
Yes	55 (31.6%)	148 (20.4%)	$p=0.001$**
No	119 (68.4%)	578 (79.6%)	
Past abdominal surgery			
Yes	49 (28.2%)	202 (27.8%)	$p=0.93$
No	125 (71.8%)	524 (72.2%)	
First catheter	143 (82.2%)	604 (83.2%)	$p=0.77$

N.S not statistically significant

*$p<0.05$

**$p<0.01$

Of the 174 images taken within a time window of catheter dysfunction, ideal positioning of the tip was observed in 35%. The positive predictive value of abdominal X-ray images to predict catheter function according to the position of the catheter tip was 26% and the negative predictive value was 87%. Abdominal surgery was performed prior to 28.2% of the cases of catheter dysfunction and prior to 27.8% of the cases of normal functioning catheters. No relation was found between previous abdominal surgery and catheter function ($p=0.93$), nor between the number of previous PD catheters and catheter function ($p=0.77$) (Table 4).

Thirty-two patients (13%) had PKD, and a significant relation was observed between PKD and catheter function. Patients with PKD were more likely to have a functioning catheter than were patients without PKD ($p=0.014$). Obese patients were more likely to have catheter malfunction ($p=0.01$).

Finally, logistic regression analysis demonstrated that the location of the catheter, obesity and PKD significantly predicted catheter function ($p<0.05$).

Discussion

Peritoneal catheter dysfunction is one of the main reasons for technique failure. Traditionally, catheter malposition has been considered an explanation for catheter dysfunction. The main novel finding of our study is that malposition does not necessarily indicate dysfunction, as 74% of malpositioned catheters functioned normally. Conversely, malfunction is not definitely due to malposition, since more than one-third (35%) of malfunctioning catheters were located in an ideal position (the small pelvis).

Our results concur with those of Twardowski, who demonstrated that 20% of catheters were located in the upper abdominal quadrants in a random abdominal X-ray examination, but only 20% of those "malpositioned" catheters were functionally obstructed [13]. More recently, Qayyum et al. [14] reported that 33–46% of peritoneal catheters were not located in an ideal position, while only one-third of them were not functioning normally. We suggest some possible explanations for our findings and those of others. First, the static nature of abdominal X-ray imaging may not adequately reflect the location of a dynamically moving catheter tip. Actually, almost all organs surrounding a dialysis catheter are mobile, even voiding changes the position. This was confirmed by cystographies performed in 47 patients during our study period as part of a pre-transplant evaluation. Cystography is a dynamic test and enables observing changes in the catheter's tip position as the bladder fills and empties (Fig. 2). These images showed that in more than one-half (56%), the catheter tip was located in the small pelvis at the first step of cystography and eventually migrated during the procedure. Thus, a static abdominal x-ray may capture the full bladder or an empty bladder with a changed position. Another possibility is that the function of the catheter is affected less by the anatomical position of the catheter, and more prominently by its dynamic environment, including adhesions and motility of intestines. The angle of the catheter tip may also affect its function, as was demonstrated by Bammens et al. [15]. Another interesting observation of our study is the correlation between normal catheter function and PKD. The suitability of PD in PKD patients has been actively discussed; the general conclusion is that peritoneal dialysis is a possible renal replacement therapy option for PKD patients [16–19]. Despite a higher risk of abdominal wall hernia in these patients, technique survival is similar to that in patients with non-cystic diseases. Our report describes better PD catheter function in PKD patients than in other patients. The explanation of this phenomenon is unclear. Partially, it may be due to the higher prevalence of the "ideal" position of the catheter tip (62% in PKD vs 50.3% in non-PKD, $p = 0.007$). Notably, the number of patients was small, only 32 (13%), so further investigation of this issue is needed.

Our data also demonstrated a higher likelihood of catheter malfunction in patients with obesity. The evidence is sparse about this issue. A recent study by Krezalek et al. [20] did not find statistically significant differences in catheter dysfunction by body mass index (BMI) category; also Sakaci et al. [21] demonstrated similar technique survival in patients with increased BMI at the initiation of PD, as patients with normal BMI. More data are needed to achieve more conclusive results.

Regarding the impact of past abdominal surgery on catheter function, our data confirmed the concept [22, 23] that abdominal surgery is not an absolute contraindication for PD. The occurrence of adhesions is unpredictable and has great individual variability. Scars on the abdomen from a previous surgery do not predict the existence and extent of adhesions and should not be used to determine eligibility for PD [22].

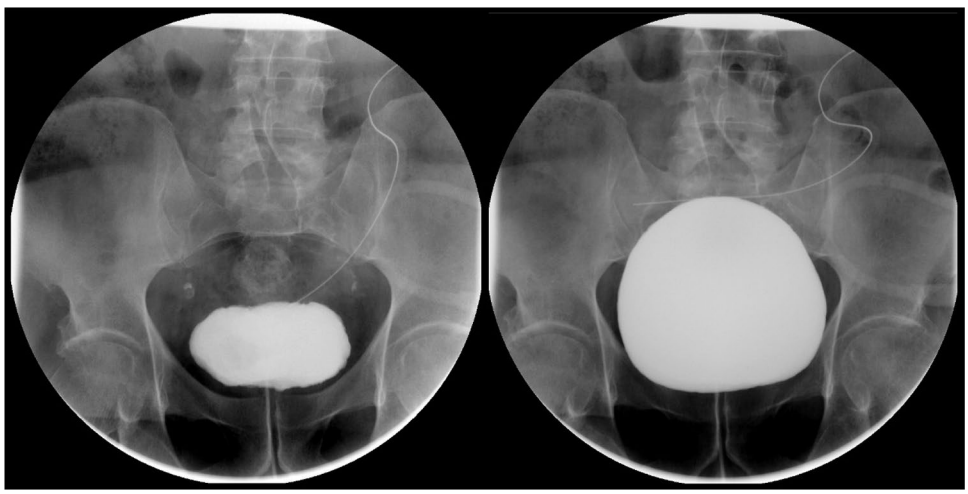

Fig. 2 Cystography demonstrates changes in the position of the catheter's tip in the same patient, from the small pelvis to another site, as the bladder fills and empties

Limitations of this study include its retrospective nature. Also, the possibility of selection bias arises due to repeated imaging performed to the same patient, both during normal function and malfunction of the catheter. However, since the catheter was located at different locations on different random images in the same patients, which at several times did not have an impact on catheter function, we decided to include all imaging in the analyses.

Conclusions

In conclusion, malposition of a catheter does not necessarily predict abnormal functioning, as it is prominently affected by its dynamic environment. Our data confirm that the probability of a normal functioning peritoneal catheter is higher if its tip is located in the small pelvis; however, also "malpositioned" catheters generally function well, and a "malposition" of the PD catheter does not in itself indicate malfunction. Since environmental factors (omentum, adhesions, intestine, bladder) may have greater effects than anatomical position alone, a simple static definition of anatomical location of the catheter is not sufficient. Thus, it seems more important to remove a malfunctioning catheter from the problematic environment—regardless of its anatomical location—since achieving the "ideal" location in the small pelvis may not solve the problem of malfunctioning.

PKD patients appear to have a propensity for less functional problems of the dialysis catheter; while patients with obesity appear to have a greater probability of having a catheter function problem.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study was done in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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