see commentary on page 880

Postimplantation X-ray parameters predict functional catheter problems in peritoneal dialysis

Bert Bammens[1,2], Domien Peeters[1], Joris Jaekers[3], Kathleen J. Claes[1,2], Pieter Evenepoel[1,2], Dirk Kuypers[1,2], Björn Meijers[1,2], Maarten Naesens[1,2], Yves Vanrenterghem[1,2] and Diethard Monbaliu[3,4]

[1]Department of Nephrology, Dialysis and Renal Transplantation, University Hospitals Leuven, Leuven, Belgium; [2]Laboratory of Nephrology, Department of Microbiology and Immunology, KU Leuven, Leuven, Belgium; [3]Department of Abdominal Transplant Surgery, University Hospitals Leuven, Leuven, Belgium and [4]Laboratory of Abdominal Transplantation, Department of Microbiology and Immunology, KU Leuven, Leuven, Belgium

Functional catheter problems are a major challenge for peritoneal dialysis (PD) programs. Here we performed a retrospective single-center study of 110 consecutive patients receiving a first PD catheter (swan neck double-cuff Missouri curled catheters, open surgical technique). Using postimplantation X-ray, the following categories were defined: swan neck angle (posterioanterio view (PA): under 45°, 45–90°, over 90°), inclination (angle between intramural part of catheter and horizontal line; lateral view: greater than/equal to 30°, under 30°), and the position of silicone bead relative to spine (PA view: L1-2, L3-4, lower) and catheter tip (PA view: hypogastric, umbilical, subcostal). Covariates included demographics, body size, previous abdominal surgery, and abdominal wall hernias. During a mean follow-up of 36 months, the time to first functional catheter problem was significantly associated with both the swan neck angle and inclination. The need for surgical intervention was significantly associated with inclination only. Technique failure was not associated with any parameter. In multivariate analysis, inclination was the sole variable significantly associated with functional catheter problems (hazard ratio 3.65 [1.98–6.72]) and the need for surgical intervention (hazard ratio 2.86 [1.19–6.88]). Thus, our study defines a set of X-ray variables that predict functional PD catheter problems and can be used for troubleshooting in individual cases as well as for education and internal audit purposes.

Kidney International (2014) **86,** 1001–1006; doi:10.1038/ki.2014.203; published online 18 June 2014

KEYWORDS: catheter; functional catheter problems; peritoneal dialysis; shape memory; swan neck

Correspondence: *Bert Bammens, Department of Nephrology, Dialysis and Renal Transplantation, University Hospitals Leuven, Herestraat 49, Leuven 3000, Belgium. E-mail: bert.bammens@uzleuven.be*

Received 4 July 2013; revised 29 March 2014; accepted 3 April 2014; published online 18 June 2014

A reliable access to the peritoneal cavity is a prerequisite for successful peritoneal dialysis (PD) treatment. Unfortunately, problems with PD catheters are frequently encountered and are identified as one of the issues limiting growth of PD in many centers.[1,2] Increasing numbers of publications on the issue illustrate the growing awareness of this problem, as do the Clinical Practice Guidelines for Peritoneal Access published recently by the International Society of Peritoneal Dialysis (ISPD).[3] The document points to the importance of an adequate 'access team', timely referral for catheter placement, reliance on clear protocols for perioperative catheter care, and local expertise governing the choice of method of catheter placement.[4–6] As to which catheter type is to be preferred, the guidelines state that no particular type has been proven to be better than another, although it is recommended to use a catheter of appropriate size.[3,7] Although it is well recognized that the so-called 'shape memory' of PD catheters should be respected to prevent catheter migration and malfunction,[8] this is not mentioned in the current ISPD guidelines.

In accordance with Guideline 7, we organized a local audit on the outcome after PD catheter insertion.[3] In addition, we questioned whether baseline abdominal X-ray parameters reflecting adherence to the intrinsic catheter shape and its position could be identified. We investigated whether these parameters could predict functional catheter problems, the consequent need for surgical intervention, and technique failure. The ultimate goal was to establish a novel set of parameters that could be used for troubleshooting in individual cases of functional PD catheter problems as well as for educational and internal audit purposes.

RESULTS

Patient population

Between January 2005 and July 2010, 116 swan neck double-cuff Missouri curled PD catheters were placed in our center. Second catheter placements ($n = 3$) and patients whose medical follow-up was carried out in another center after catheter placement ($n = 3$) were excluded from the present analysis. Baseline demographic and clinical data from the 110 patients included in the analysis are shown in Table 1.

Table 1 | Demographic and clinical data

Variable	Unit	Value
Age	Years	56 ± 16
Gender	Male (%)	64 (58)
Renal diagnosis	dm/eci/gn/in/ms/neo/PKD/other congen (%)	13/35/26/5/10/1/13/7 (12/32/23/5/9/1/12/6)
Diabetes mellitus	Present (%)	24 (22)
CV history	Present (%)	51 (46)
Hypertension	Present (%)	56 (51)
Weight	kg	69 ± 14
BMI	kg/m^2	24 ± 4
CrCl	ml/min	9.3 ± 5.5
Previous abd surgery	Present (%)	41 (37)
	Laparoscopic/open/none (%)	2/39/69 (2/35/63)
	cr/gyn/hb/uro/other/none (%)	9/7/2/15/8/69 (8/6/2/14/7/63)
Hernia	Present (%)	7 (6)
	Inguinal/umbilical/incisional/none (%)	2/4/1/103 (2/3/1/94)
PD modality	CAPD/APD (%)	44/65

Abbreviations: abd, abdominal; BMI, body mass index; CAPD, continuous ambulatory peritoneal dialysis; congen, congenital; cr, colorectal; CrCl, creatinine clearance; CV history, cardiovascular history; dm, diabetes mellitus; eci, e causa ignota; gn, glomerulonephritis; gyn, gynecological; hb, hepatobiliary; in, interstitial nephritis; ms, multisystem; neo, neoplastic; PD, peritoneal dialysis; PKD, polycystic kidney disease; uro, urological.

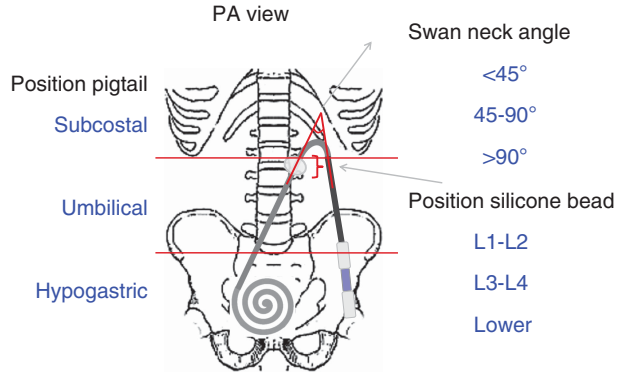

Figure 1 | Schematic representation of the three radiological parameters assessed from plain abdominal X-ray in posterioanterio (PA) view: swan neck angle, position of the silicone bead, and position of the catheter tip. See Materials and Methods section for more details.

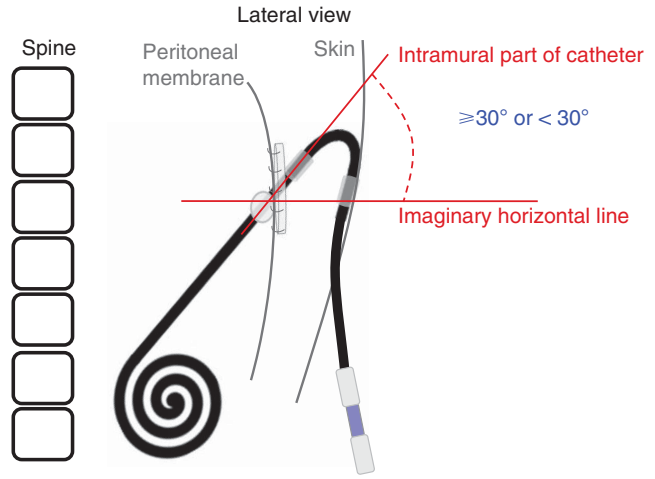

Figure 2 | Schematic representation of the inclination, i.e. angle of the intramural part of the PD catheter with an imaginary horizontal line, as assessed from abdominal X-ray in lateral view. See Materials and Methods section for more details.

Postimplantation X-ray parameters

Parameters assessed from plain abdominal X-ray were swan neck angle, position of the silicone bead and position of the catheter tip in posterioanterio (PA) view, and inclination in lateral view (for detailed definition: see Materials and Methods and Figures 1 and 2). Swan neck angle in PA view was $<45^\circ$ in 57%, 45–90° in 23%, and $>90^\circ$ in 20% of the patients. Inclination in lateral view was $\geqslant 30^\circ$ in 74% and $<30^\circ$ in 26% of the patients. As shown in Tables 2 and 3, patients in whom the catheter 'shape memory' appeared to be least respected (swan neck angle $>90^\circ$, inclination $<30^\circ$) weighed significantly more and had higher body mass index than the other categories. Moreover, there were weak associations of swan neck angle with renal diagnosis (polycystic kidney disease vs. other) and of inclination with history of abdominal surgery. In 25% of the patients, the position of the silicone bead in PA view was at L1-2, in 60% it was at L3-4, and it was lower in 15%. The position of catheter tip in PA view was hypogastric in 63% of the patients, umbilical in 31%, and subcostal in 6%. The silicone bead position was significantly related only with age ($P = 0.01$) and catheter tip position only with history of abdominal surgery ($P = 0.04$).

Outcome parameters

During follow-up from date of implantation until 10/2010 (mean follow-up of 36 ± 17 months), 42 patients (38%) experienced at least one documented clinically overt functional catheter problem. In 21 patients (19%), conservative management with laxatives was unsuccessful and surgical intervention was needed. In 19 of these patients, displacement of the PD catheter was the reason for the malposition found intraoperatively. In four procedures, some adhesions were removed as well, but they were found not to be the cause of the displacement. In one of the two remaining