Original Article

PERITONEAL DIALYSIS INTERNATIONAL

Peritoneal Dialysis International
2021, Vol. 41(6) 564–568

DOI: 10.1177/0896860821993946
journals.sagepub.com/home/ptd
SAGE

Diagnostic capability of ultrasound in peritoneal catheter malfunction compared to videolaparoscopy

Matthias Zeiler[1], Antonio Federico[1], Paolo Lentini[2], Roberto Dell'Aquila[2], Stefano Santarelli[1] and Antonio Granata[3] and for the Project Group 'Integrated Imaging and Interventional Nephrology' of the Italian Society of Nephrology

Abstract

Background: The approach to peritoneal catheter malfunction consists usually in a diagnostic and therapeutic sequence of laxative prescription, abdominal radiography, brushing of the catheter, guide-wire manipulation or fluoroscopy and in the end of a videolaparoscopy (VLS) rescue intervention. Ultrasound (US) is able to find out major causes of peritoneal catheter malfunction, however without a clearly defined diagnostic value. The aim of the study was to validate the diagnostic capability of US in catheter malfunction compared to the diagnostic reference of VLS.

Methods: US scans of the subcutaneous and intraperitoneal segment of the catheter were performed prior to a VLS intervention in 40 adult patients presenting persistent catheter malfunction within a prospective multicentre study. Laxative prescription and brushing of the catheter lumen were undertaken prior to US scan. US diagnosis was compared to the corresponding at VLS, kappa coefficient calculated and the causes of mismatch analysed.

Results: In US, causes of persistent malfunction were catheter dislocation combined with omental wrapping in 21 cases, omental wrapping without dislocation in 11 cases, dislocation only in 4 cases, adherences to non-omental structures in 3 cases and entrapment in the lateral inguinal fossa in 1 case. The US diagnosis corresponded to the respective at VLS in 36 of 40 cases, resulting in a kappa coefficient of 0.89 (95% CI: 0.78–1.00). The discrepancies were due to improper visualization of the catheter between omentum and intestinal loops, resulting in an erroneous US diagnosis of omental wrapping.

Conclusions: This study suggests that US might have a pivotal role in the diagnostic approach to peritoneal catheter dysfunction.

Keywords

Agreement, bedside, diagnosis, malfunction, peritoneal dialysis, surgery, ultrasound scan, videolaparoscopy

Introduction

Catheter malfunction compromises directly adequacy and technical survival of peritoneal dialysis (PD). Potential causes of malfunction are constipation, catheter dislocation, extrinsic compression by distended urinary bladder or colon, omental wrapping, kinking of the catheter and intraluminal fibrin clot. Possible imaging techniques are abdomen radiography, catheter peritoneography, computed tomography, magnetic resonance tomography, peritoneal scintigraphy and ultrasound (US).[1–5] Videolaparoscopy (VLS) is the 'gold' standard of a combined diagnostic and therapeutic approach in catheter malfunction.[6,7] US remains, beside physical examination, the only bedside diagnostic technique of the peritoneal catheter.

US of the catheter tunnel is already an acknowledged diagnostic procedure.[8–10] The examination of catheter malfunction by US has been reported for the first time in paediatric patients, recently in adult patients.[2,3] In expert hands, US is highly accurate for the evaluation of catheter

[1] Nephrology and Dialysis Unit, 'Carlo Urbani' Hospital, Jesi, Italy
[2] Nephrology and Dialysis Unit, 'San Bassiano' Hospital, Bassano del Grappa, Italy
[3] Nephrology and Dialysis Unit, 'Cannizzaro' Hospital, Catania, Italy

Corresponding author:
Matthias Zeiler, Nephrology and Dialysis Unit, 'Carlo Urbani' Hospital, Via Aldo Moro n. 52, I-60035 Jesi, Italy.
Email: mrhz1@yahoo.com

position.[4] Besides catheter dislocation, other causes of malfunction such as omental wrapping, intraluminal fibrin clot, adhesions or urinary retention can be ascertained by US.[2–4] As we started to perform routinely US examination in the case of catheter malfunction, we intended to validate the diagnostic capability of US compared to the 'gold' standard of VLS.

Methods

Three Italian Nephrology and Dialysis Units, on behalf of the Project Group 'Integrated Imaging and Interventional Nephrology' of the Italian Society of Nephrology, collaborated in this prospective observational case series. Patients who presented persistent PD catheter malfunction, mainly due to outflow and combined inflow–outflow obstruction, underwent abdomen US focusing on causes of malfunction before VLS rescue intervention. Persistent catheter malfunction was defined as ongoing catheter dysfunction despite laxative prescription and brushing of the catheter lumen. Brushing was undertaken in the attempt to liberate the catheter from intraluminal thrombus formation.

US was performed by four nephrologists (MZ, AF, PL and AG) in the PD facility. The teaching of the specific US examination was performed by MZ and AG for each investigator in 10–15 different cases.

The examination did not change the course of the patient already requiring VLS catheter revision. The work was performed in accordance with the ethical guidelines of our institutions and the 1975 Helsinki Declaration and its later amendments. An informed consent was obtained from each participant.

A total of 40 adult PD patients (27 males, 13 females, mean age: 51 years, mean body mass index: 25.3) were examined prior to VLS rescue intervention. The US examination was performed in supine position after having filled the abdomen with 1 L of dialysis fluid.[4] The catheter was followed, starting from the exit site up to the catheter tip, with sectorial or linear probes of 1–13 MHz. The US equipment used in this study consisted in a General Electric Logiq P7 (sectorial probe 4C-RS with 2–5.5 MHz, linear probe L6-12-RS with 6–13 MHz, GE Medical Systems Co. Ltd, Jiangsu, China), an Acuson S3000 Ultrasound System (sectorial probe 6C2 with 6–2.5 MHz, linear probe 9L4 with 9–4 MHz, Acuson-Siemens, Mountain View, California, USA) and a Esaote MyLab 25 (sectorial probe CA631 with 8–1 MHz, linear probe LA523 with 13–4 MHz, Esaote S.r.L. Genua, Italy).

All patients had a double-cuff straight peritoneal catheter implanted, in the majority of cases by open surgery (36 cases), followed by basic laparoscopy (3 cases) and by advanced laparoscopy including omentopexy (1 case). Catheter kinking in the abdominal wall was excluded by US as the catheter was followed from the exit site to the intraperitoneal entrance site. The intra-abdominal position, adhesion of echoic structures to the catheter and the presence of intraluminal material were documented, and an US-based diagnosis was formulated. Dislocation was defined as catheter tip position out of the lower abdomen according to a previously published scheme.[4] In patients who presented a filled urinary bladder at examination a post-void US was performed to exclude urinary retention. The time needed for US examination is 15–20 min.

The US diagnosis was compared to the corresponding at VLS intervention, and the causes of mismatch were analysed.

The VLS intervention was performed under general anaesthesia utilizing a one or two port laparoscopic access as previously published by our group.[6] Depending upon the cause of malfunction, catheter replacement combined with adhesiolysis, omentopexy and/or loop fixation was carried out. As all access sites were closed watertight, PD was restarted after the VLS procedure on the same day.

Statistical methods

The kappa coefficient was calculated to evaluate the agreement between US and VLS, with a maximum of 1.0 for perfect agreement and a minimum value of 0 for absent agreement. The level of agreement was classified in almost perfect (kappa coefficient > 0.80), substantial (0.61–0.80), moderate (0.41–0.60), fair (0.21–0.40) and slight (0.01–0.20). The data were processed using the Statistical Package for Social Sciences version 19 (SPSS, Chicago, Illinois, USA).

Results

The investigators localized the catheter in all patients. At US examination, malfunction derived from catheter dislocation combined with adhesion of omentum in 21 cases, adhesion of omentum in absence of catheter dislocation in 11 cases, dislocation only in 4 cases, adherences to non-omental structures in 3 cases and entrapment in the lateral inguinal fossa in 1 case. The catheter was found to be dislocated out of the lower abdomen in 25 cases at US scan, respectively, in the right lumbar region in 13 cases, in the umbilical region in 1 case and in the left lumbar region in 11 cases. VLS confirmed the catheter position indicated by US in all cases. The US diagnosis corresponded to the respective at VLS in 36 of 40 cases, resulting in a kappa coefficient of 0.89 (95% CI: 0.78–1.00) (detailed results in Table 1).

Regarding the four cases of mismatch, the incorrect US diagnosis was adhesion of omentum, whereas VLS showed adherence of the catheter to intestinal loops in three cases and to tubal structures in one case (Table 1). The discrepancies were due to improper visualization of the catheter. Despite filling of the abdomen with 1 L of PD fluid, the catheter remained entrapped between the intestinal loops and the omentum. Figure 1 depicts three different cases of

Table 1. Concordance and mismatch between ultrasound and videolaparoscopy diagnosis.

Diagnosis	US	VLS	Concordance	Mismatch	Kappa coefficient
Dislocation and omental wrapping	21	20	20	+1	0.95 (0.85–1.00)[a]
Omental wrapping without dislocation	11	8	8	+3	0.79 (0.58–1.00)[a]
Adhesion of non-omental structures	3	7	3	−4	0.55 (0.18–0.92)[a]
Dislocation only	4	4	4	0	1.00 (1.00–1.00)[a]
Entrapment in recessus inguinalis	1	1	1	0	1.00

US: ultrasound; VLS: videolaparoscopy.
[a]95% confidence interval.

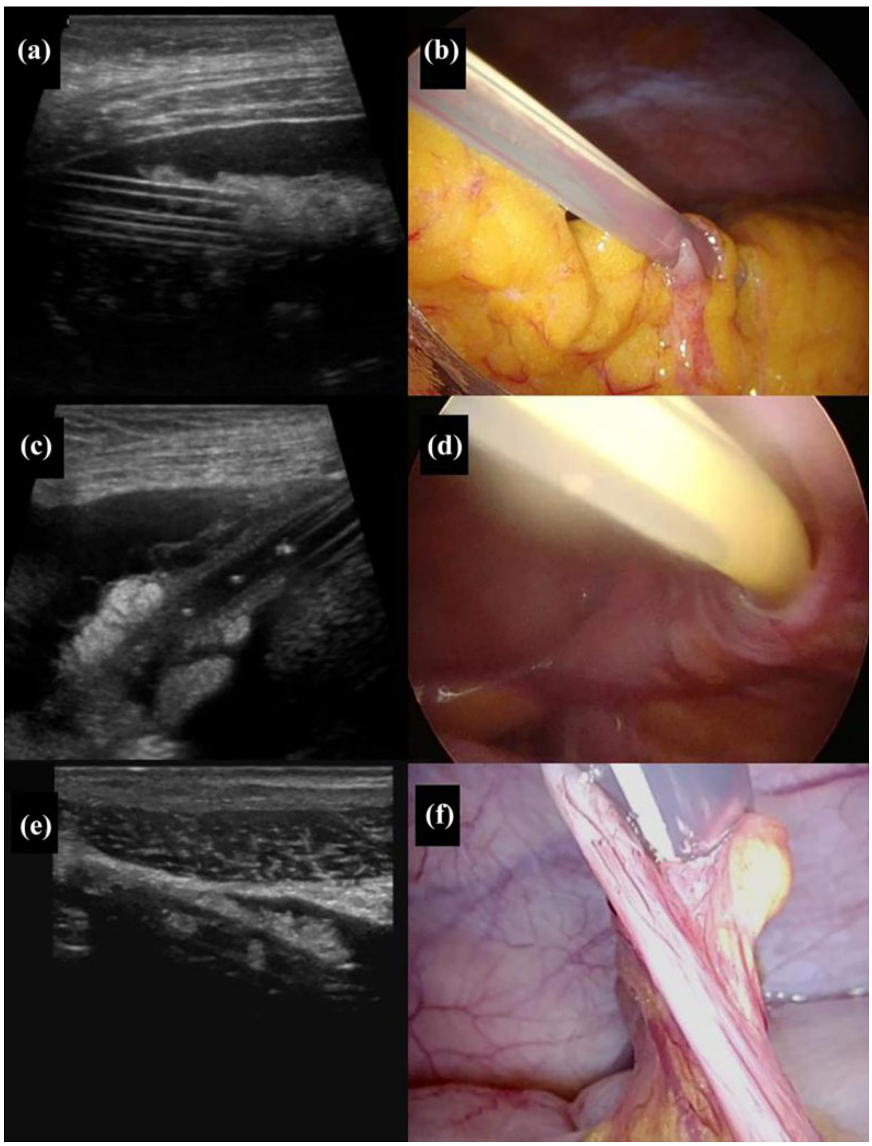

Figure 1. Ultrasound examination of peritoneal catheter malfunction (left side) and the corresponding view at videolaparoscopy intervention (right side). (a) and (b): Ultrasound examination with a 9-MHz linear probe, maximum scanning depth of 5 cm, showing hyper-echoic material attached around the distal part of the peritoneal catheter. Videolaparoscopy confirmed the ultrasound diagnosis of omental wrapping and entrapment of omentum in some of the catheter side holes. (c) and (d): Ultrasound examination with a 9-MHz linear probe, maximum scanning depth of 5 cm, showing hyper-echoic tissue attached around the distal part of the catheter and presence of a thin layer around the proximal part of catheter. Videolaparoscopy confirmed omental wrapping and fibrin sheath formation. (e) and (f): Ultrasound examination with a 12-MHz linear probe, maximum scanning depth of 4 cm, showing hyper-echoic tissue around the catheter and oval hyper-echoic structures in the catheter lumen (matching with some of the catheter side holes) despite preceding catheter brushing. Videolaparoscopy evidenced omental wrapping and entrapment of omental tissue inside the catheter lumen across the side-holes.

catheter malfunction at US examination and the corresponding view at VLS.

Discussion

Many causes of catheter malfunction such as kinking, dislocation, adhesion of omentum, fibrin sheath formation and obstruction of the lumen can easily be ascertained by US,[2–4] but the diagnostic accuracy of US has never been verified against a diagnostic reference such as VLS. For the first time, a prospective study compares the diagnostic capabilities of US directly to VLS.

The overall agreement between US and VLS was almost perfect, thus confirming the diagnostic validity of US. In detail, only the strength of agreement regarding the diagnosis 'adhesion of non-omental structures' has to be classified as moderate. An increased filling with 2 L, instead of only 1 L, and a pre-examination intestinal purge prescription similar to a cleansing regimen for colonoscopy, instead of a simple enema, might have further increased the accuracy of US. Anyway, there will always remain some difficulties of US in patients with severe obesity, constipation or curled catheter tip configuration. In the latter case, the three-dimensional configuration of the curled tip has to be virtually reconstructed by the observer as the US scan represents only a two-dimensional sector view.

Application of US for catheter malfunction was evaluated for the first time by Esposito et al. in a small study limited to 12 children.[3] In this study, US evidenced malfunction caused by intra- and extra-luminal thrombus formation in eight cases and by dislocation combined with adhesion of omentum in four cases. All catheters, despite one, regained function after forceful irrigation of saline and fibrinolytic therapy. Regarding the single case of persistent malfunction, VLS confirmed the US diagnosis of omental wrapping. In our study, the absence of intraluminal fibrin thrombi seems to be related to the prior catheter brushing procedure.

Our data reconfirm the validity of US for the evaluation of catheter position. Recently, our group evaluated the agreement between US and abdomen X-ray for catheter position demonstrating an almost perfect agreement, and thus suggesting that abdomen X-ray can be replaced by US in experienced hands.[4]

The latest International Society for Peritoneal Dialysis guideline on creating and maintaining optimal PD access indicates for catheter flow dysfunction a gradual diagnostic-therapeutic approach starting with non-invasive work up and concluding with invasive interventions.[7] Our experience suggests that US should be integrated into the non-invasive diagnostic work up. US seems to offer a wider diagnostic capability than abdomen X-ray.[4] Theoretically, the diagnostic capability of US might be comparable to diagnostic fluoroscopy,[5] but comparative studies are missing.

The value of US for catheter malfunction may be to confirm the necessity of VLS and to anticipate the specific intervention required. Furthermore, US might control the efficacy of non-invasive treatment procedures such as fibrinolysis, catheter flushing, brushing or guide-wire manipulations. The final step of diagnosis and treatment remains attributed to VLS.

US is helpful in making a correct preoperative diagnosis of catheter malfunction. In clinical practice, patient consensus should be based on a case-specific diagnostic work-up resulting in a correct preoperative diagnosis. From a surgical viewpoint, the knowledge of the causes of catheter malfunction might be helpful in planning and preparation of an advanced VLS rescue intervention which includes adhesiolysis, epiploectomy, salpingectomy, omentopexy, omentectomy and catheter fixation.

Conclusions

This study suggests that US might have a pivotal role in the diagnostic approach to peritoneal catheter dysfunction. US might also represent a diagnostic tool to evaluate the indications of VLS.

Acknowledgement

The authors would like to thank the nursing staff of the collaborating Nephrology and Dialysis Units for their assistance in this research.

Author contributions

Matthias Zeiler, Antonio Federico, Paolo Lentini and Antonio Granata designed the work, analysed the data and drafted the article. Matthias Zeiler, Roberto dell'Aquila and Stefano Santarelli revised the article and approved the version to be published. Matthias Zeiler was appointed as the corresponding author.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

The regional public health system 'Azienda Sanitaria Unica Regionale – ASUR' does not require ethical approval for reporting case series. Nevertheless, this work was completed in accordance with the Helsinki Declaration as revised in 2013.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Informed consent to participate

Written informed consent was obtained from all subjects before the study.

Informed consent to publish

Written informed consent was obtained from the patients for their anonymized information to be published in this article.

ORCID iD

Matthias Zeiler https://orcid.org/0000-0001-6066-6144

References

1. Scanziani R, Pozzi M, Pisano L, et al. Imaging work-up for peritoneal access care and peritoneal dialysis complications. *Int J Artif Organs* 2006; 29(1):142–152.
2. Esposito F, Di Serafino M, Sgambati P, et al. Ultrasound in the diagnosis of peritoneal catheter obstruction in children. *Kidney Int* 2012; 82(4): 499.
3. Esposito F, Di Serafino M, Ambrosio C, et al. Chronic peritoneal dialysis in children: the role of ultrasound in the diagnosis of peritoneal catheter obstruction. *J Ultrasound* 2016; 19(3): 191–196.
4. Zeiler M, Zanoli L, Scarfia RV, et al. Peritoneal dialysis catheter position evaluated by ultrasound: can it replace abdomen X-ray in patients presenting catheter misplacement? *Ultraschall Med* 2017; 38(5): 538–543.
5. Degesys GE, Miller GA, Ford KK, et al. Tenckhoff peritoneal dialysis catheters: the use of fluoroscopy in management. *Radiology* 1985; 154(3): 819–820.
6. Santarelli S, Zeiler M, Marinelli R, et al. Videolaparoscopy as rescue therapy and placement of peritoneal dialysis catheters: a thirty-two case single centre experience. *Nephrol Dial Transplant* 2006; 21(5): 1348–1354.
7. Crabtree JH, Shrestha BM, Chow KM, et al. Creating and maintaining optimal peritoneal dialysis access in the adult patient: 2019 update. *Perit Dial Int* 2019; 39(5): 414–436.
8. Vychytil A, Lorenz M, Schneider B, et al. New criteria for management of catheter infections in peritoneal dialysis patients using ultrasonography. *J Am Soc Nephrol* 1998; 9(2): 290–296.
9. Kwan TH, Tong MK, Siu YP, et al. Ultrasonography in the management of exit site infections in peritoneal dialysis patients. *Nephrology (Carlton)* 2004; 9(6): 348–352.
10. Karahan OI, Taskapan H, Yikilmaz A, et al. Ultrasound evaluation of peritoneal catheter tunnel in catheter related infections in CAPD. *Int Urol Nephrol* 2005; 37(2): 363–366.