Canadian Society of Nephrology/ Société canadienne de néphrologie CSN/SCN

CANADIAN JOURNAL OF KIDNEY HEALTH AND DISEASE
Journal canadien de la santé et de la maladie rénale

Original Clinical Research Quantitative

Canadian Journal of Kidney Health and Disease
Volume 7: 1–7

DOI: 10.1177/20543581209641 15
journals.sagepub.com/home/cjk
SAGE

Utility of Abdominal Imaging in Peritoneal Dialysis Patients Presenting With Peritonitis

Emilie Trinh[1] and Joanne M. Bargman[2]

Abstract

Background: Peritonitis remains a major complication in peritoneal dialysis (PD). Abdominal imaging is often performed in the setting of peritonitis to evaluate for concomitant intra-abdominal processes. However, the usefulness of this procedure is unknown.

Objective: The aim of this study was to assess the prevalence of abdominal imaging performed in the setting of PD peritonitis and to evaluate clinical parameters associated with abnormal imaging results to identify clinical situations in which radiographic examinations are informative.

Design: This is a retrospective cohort study.

Setting: The study was conducted at the Toronto General Hospital, Ontario, Canada.

Patients: We studied 166 episodes of PD peritonitis in 114 patients between January 1, 2011, and June 30, 2016.

Measurements: Baseline demographics, characteristics of PD peritonitis, and characteristics of abdominal imaging performed.

Methods: The association between relevant clinical parameters and abnormal abdominal imaging was examined using a univariate and multivariate logistic regression model.

Results: Abdominal imaging (computed tomography [CT] scan or ultrasound) was performed in 68 cases (41%). Patients were more likely to undergo imaging if they required hospitalization, were admitted to the intensive care unit (ICU), had polymicrobial or fungal organisms causing peritonitis, had relapsing/recurrent/refractory peritonitis, had an indication for hemodialysis or PD catheter removal, or presented with hypotension, tachycardia, or an elevated serum lactate. Of the imaging performed, abnormalities were found in 32 cases (47%). The most common findings were bowel obstruction, intra-abdominal collection, and biliary abnormalities. In the univariate analysis, ICU admission (43.3% vs 14.3%, $P < .01$) and need for temporary or permanent hemodialysis (62.5% vs 30.6%, $P < .01$) were associated with imaging abnormalities. Importantly, the peritonitis organism was not associated with abnormal imaging results. In a multivariate analysis, ICU admission was the only significant clinical parameter associated with imaging abnormalities with an odds ratio (OR) of 4.4 (95% confidence interval [CI]: 1.1-17.4, $P = .04$).

Limitations: Single-center study, small sample size, and lack of detailed information on the exact indications leading to abdominal imaging.

Conclusions: Abdominal imaging is commonly performed in the setting of PD peritonitis. Abnormalities are not infrequent and are present in almost half of the cases, with need for ICU admission being the most significant clinical parameter associated with abnormal findings. Therefore, abdominal imaging should be performed in carefully selected patients with PD peritonitis, especially if there is evidence of hemodynamic instability. While the finding of fungal or polymicrobial peritonitis was a driver for abdominal imaging, the presence of these organisms did not predict radiologic abnormalities.

Abrégé

Contexte: La péritonite demeure une des principales complications de la dialyse péritonéale (DP), et l'imagerie abdominale est couramment utilisée pour évaluer la présence de processus intra-abdominaux concomitants.

Objectifs: Établir la prévalence de l'imagerie abdominale dans les cas de péritonites liées à la DP et déterminer les paramètres cliniques associés à des résultats d'imagerie anormaux afin d'identifier les situations cliniques pour lesquelles les examens radiographiques sont informatifs.

Type d'étude: Étude de cohorte rétrospective.

Cadre: L'hôpital général de Toronto (Ontario) au Canada.

Sujets: Nous avons examiné 166 épisodes de péritonites liées à la DP survenues chez 114 patients entre le 1er janvier 2011 et le 30 juin 2016.
Mesures: Les données démographiques des patients, les caractéristiques de la péritonite et les caractéristiques de l'imagerie abdominale effectuée.
Méthodologie: Le lien entre les paramètres cliniques pertinents et une imagerie abdominale anormale a été établi à l'aide de modèles de régression logistique univariée et multivariée.
Résultats: Une imagerie abdominale (tomodensitométrie ou échographie) a été effectuée dans 68 cas (41 %). Les patients étaient plus susceptibles de subir un examen d'imagerie s'ils devaient être hospitalisés ou admis à l'unité des soins intensifs (USI), si la péritonite était causée par une infection fongique ou polymicrobienne, s'il s'agissait d'une péritonite récurrente/réfractaire ou d'une rechute, s'ils avaient une indication d'hémodialyse ou de retrait du cathéter de DP, ou s'ils présentaient de l'hypotension, de la tachycardie ou un taux élevé de lactate sérique. Une anomalie a été détectée dans 32 (47 %) des tests d'imagerie effectués; une occlusion abdominale, une collection intra-abdominale ou une anomalie biliaire étant les plus fréquemment observées. Dans l'analyse univariée, une admission aux USI (43,3 % vs 14,3 %; $P < 0,01$) et le besoin d'hémodialyse temporaire ou permanente (62,5 % vs 30,6 %; $P < 0,01$) ont été associés à des anomalies détectées lors de l'imagerie. La présence de microorganismes causant la péritonite n'a toutefois pas été associée à des résultats d'imagerie anormaux. Dans l'analyse multivariée, seule une admission aux USI a été significativement associée à un résultat d'imagerie anormal, avec un rapport de cotes de 4,4 (IC 95 %: 1,1-17,4; $P = 0,04$).
Limites: Étude monocentrique, échantillon de faible taille et manque d'informations détaillées sur les indications pour l'imagerie abdominale.
Conclusion: L'imagerie abdominale est couramment pratiquée en présence d'une péritonite liée à la dialyse péritonéale. Des anomalies sont observées dans près de la moitié des cas et l'admission aux soins intensifs constitue le paramètre clinique le plus significativement associé à un résultat d'imagerie anormal. Dès lors, l'imagerie abdominale devrait être envisagée pour certains patients soigneusement sélectionnés présentant une péritonite liée à la DP, particulièrement s'il y a instabilité hémodynamique. Enfin, bien qu'un diagnostic de péritonite fongique ou polymicrobienne soit un moteur d'imagerie abdominale, la présence de ces microorganismes ne s'est pas avérée prédictive d'anomalies radiologiques.

Keywords
imaging, peritonitis, peritoneal dialysis

Received April 8, 2020. Accepted for publication August 8, 2020.

What was known before

Abdominal imaging is often performed in the setting of peritonitis, but its utility in this setting is currently unknown.

What this adds

Abdominal imaging should be performed in carefully selected patients with peritoneal dialysis (PD) peritonitis, especially if there is evidence of hemodynamic instability.

Introduction

Peritonitis remains a major complication in peritoneal dialysis (PD) and is associated with increased hospitalizations, technique failure, and mortality.[1-4] While imaging modalities do not play a role in the diagnosis of peritonitis,[5] abdominal imaging is often performed in the setting of peritonitis to evaluate for other concomitant intra-abdominal processes or to rule out any superimposed infectious complications. Experience in hemodialysis patients has shown that dialysis patients undergo frequent imaging with estimated radiation doses that may increase the risk of cancer.[6] Thus, imaging should be performed only when clinically indicated.[7] As the utility of abdominal imaging in the setting of PD peritonitis is unknown, the aim of our study was to assess the prevalence of abdominal imaging performed in the setting of PD peritonitis and to evaluate clinical parameters associated with abnormal imaging results to identify clinical situations in which radiographic examinations are informative.

[1]Division of Nephrology, McGill University Health Center, McGill University, Montreal, QC, Canada
[2]Division of Nephrology, University Health Network, Toronto, ON, Canada

Corresponding Author:
Joanne M. Bargman, Division of Nephrology, University Health Network, 200 Elizabeth Street, 8N-840, Toronto, ON, Canada M5G 2C4.
Email: joanne.bargman@uhn.ca

Methods

This retrospective cohort study included all PD patients who presented with peritonitis at the Toronto General Hospital from January 1, 2011, to June 30, 2016. The primary objective was to quantify how often abdominal imaging is performed in the setting of PD peritonitis and if performed, how frequently imaging reveals any abnormalities. Our secondary objective was to evaluate clinical parameters associated with abnormal imaging in PD peritonitis. Our hypothesis was that abdominal imaging is frequently normal in the setting of PD peritonitis and may be performed unnecessarily.

Patient characteristics that were considered relevant were gathered from electronic records and chart review. These included age, gender, medical comorbidities, cause of end-stage kidney disease (ESKD), and dialysis vintage. Detailed information regarding the episode of peritonitis was also collected and included causative organism, need for hospitalization and length of admission, presence of hypotension or tachycardia upon initial presentation, initial serum lactate, and need for catheter removal. Tachycardia was defined as a heart rate above 100 beats per minute, and hypotension was defined as either a systolic blood pressure below 90 mm Hg or a diastolic blood pressure below 60 mm Hg. Refractory peritonitis was defined as failure of the effluent to clear after 5 days of appropriate treatment, recurrent peritonitis was defined as an episode occurring within 4 weeks of therapy with a different organism, and relapsing peritonitis was defined as an episode occurring within 4 weeks of therapy with the same organism.[4] Relapsing, refractory, and recurrent peritonitis episodes were treated as separate episodes as they were considered to be different opportunities for abdominal imaging to be performed. When abdominal imaging was performed, the type of imaging done, the date performed relative to initial presentation to hospital, and type of abnormalities were also described. As our objective was to evaluate the usefulness of abdominal imaging in the setting of PD peritonitis to look for other concomitant acute intra-abdominal processes, any deviation from normal that appeared acute was considered to be abnormal. Plain abdominal X-rays were excluded from our analysis.

Statistical Analysis

Baseline demographics and clinical characteristics are presented as means ± standard deviation (SD), medians and interquartile ranges, or proportions as appropriate. Comparisons were tested using the chi-square test for categorical variables and the Student *t* test or Kruskal-Wallis test for continuous variables. The association between relevant clinical parameters and abnormal abdominal imaging results was examined using a univariate and multivariate logistic regression model. Two-tailed *P* values of $<.05$ were considered statistically significant. All analyses were performed using Stata SE, version 14 (StataCorp, College Station, TX, USA). Approval for the study was received from the Research Ethics Board at the University Health Network.

Table 1. Characteristics of the Cohort.

Age, years (mean ± SD)	64.9 ± 17.0
Male sex (n, %)	77 (46.4%)
Cause of ESKD (n,%)	
Diabetes	56 (33.7%)
Renovascular	14 (8.4%)
Glomerulonephritis	45 (27.1%)
Polycystic kidney disease	8 (4.8%)
Other	43 (25.9%)
Comorbidities	
Diabetes	76 (45.8%)
Coronary artery disease	64 (38.6%)
Peripheral vascular disease	27 (16.3%)
Cerebrovascular disease	20 (12.0%)
Peritonitis organism	
Gram positive	68 (41.0%)
Gram negative	35 (21.1%)
Polymicrobial	27 (16.3%)
Fungal	6 (3.6%)
Fungal with other bacterial organism	7 (4.2%)
Culture negative	20 (12.0%)
Mycobacterium	3 (1.8%)
Need for hospitalization (n, %)	119 (71.7%)
Need for ICU admission (n, %)	23 (13.9%)
Length of admission (days, median [IQR])	10 (5-13)
Need for temporary or permanent HD	40 (24.1%)
Need for catheter removal	42 (25.3%)
Relapsing recurrent, or refractory peritonitis	28 (16.9%)
Abdominal imaging performed	
CT	60 (36.1%)
US	8 (4.8%)

Note. SD = standard deviation; ESKD = end-stage kidney disease; ICU = intensive care unit; IQR = interquartile range; HD = hemodialysis; CT = computed tomography; US = ultrasound.

Results

We studied 166 episodes of PD peritonitis in 114 patients at Toronto General Hospital between January 1, 2011, and June 30, 2016. Baseline characteristics of the cohort are presented in Table 1. During the study period, the average annual peritonitis rate in our center was 1 per 53.3 patient-months.

Peritonitis episodes were caused by gram-positive organisms in 41.0%, gram-negative organisms in 21.1%, polymicrobial in 16.3%, fungal in 7.8%, mycobacterium in 1.8%, and culture negative in 12.0%. Hospitalization was needed in 71.7% of cases with 13.9% requiring intensive care unit (ICU) admission. Median length of stay was 10 days (interquartile range: 5-23).

Abdominal imaging was performed in 68 cases (41%): 60 with a computed tomography (CT) scan and 8 with an

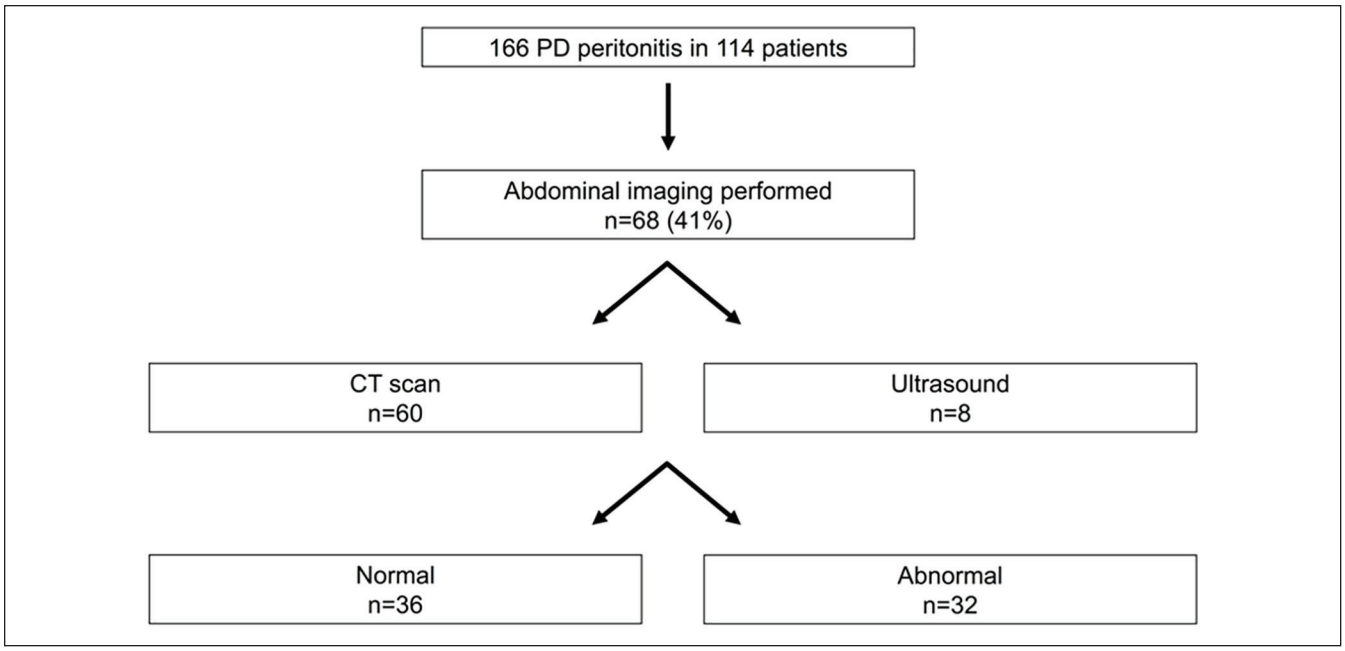

Figure 1. Patient flowchart.
Note. PD = peritoneal dialysis; CT = computed tomography.

ultrasound (Figure 1). Characteristics of patients with and without abdominal imaging are presented in Table 2. Baseline characteristics were similar between both groups. Patients were more likely to undergo imaging if they required hospitalization ($P < .01$); were admitted to the ICU ($P < .01$); had polymicrobial or fungal organisms causing peritonitis ($P < .01$); had relapsing, recurrent, or refractory peritonitis ($P < .01$); had an indication for hemodialysis or PD catheter removal ($P < .01$); or presented with hypotension, tachycardia, or an elevated serum lactate ($P = .05$). The patient flowchart is illustrated in Figure 1.

Of the imaging performed, abnormalities were found in 32 cases (47%, Figure 1). Details regarding the type of abnormalities detected are presented in Table 3. The most common findings were bowel obstruction, intra-abdominal collection, and biliary abnormalities.

Characteristics of patients with and without abnormal imaging findings are detailed in Table 4. Significant clinical parameters associated with abnormalities in the univariate analysis included ICU admission (43.3% vs 14.3%, $P < .01$) and need for temporary or permanent hemodialysis (62.5% vs 30.6%, $P < .01$). The type of causative peritonitis organism was not associated with abnormal imaging results. In a multivariate logistic regression analysis, ICU admission was the only significant parameter associated with imaging abnormalities with an odds ratio (OR) 4.4 (95% confidence interval [CI]: 1.1-17.4, $P = .04$; Table 5).

Discussion

We found that abdominal imaging is commonly performed in the setting of PD peritonitis (41% of cases) with hemodynamic instability, need for ICU admission, polymicrobial or fungal organisms, and relapsing, recurrent, or refractory peritonitis being clinical factors leading to imaging being performed. Abnormal imaging results are not uncommon and were present in almost half of the cases. The need for ICU admission was the most important clinical parameter associated with abnormal findings. Abnormal imaging findings were also associated with the need for temporary or permanent hemodialysis or PD catheter removal. While the finding of fungal or polymicrobial peritonitis was a driver for abdominal imaging, the presence of these organisms did not predict radiologic abnormalities. The most common imaging findings were bowel obstruction, intra-abdominal collection, and biliary abnormalities.

Severe clinical presentation, especially with hemodynamic instability requiring ICU admission, in the PD patient with peritonitis should prompt treating physicians to evaluate for other intra-abdominal processes. Importantly, the type of organism causing peritonitis did not predict radiologic abnormalities and thus, based on our results, should not dictate the need for abdominal imaging.

Studies in hemodialysis patients have shown that ESKD patients undergo frequent imaging with estimated radiation doses that may increase the risk of cancer.[6,8] Therefore, it is imperative to minimize unnecessary imaging. While abdominal imaging has been studied in other PD-related complications such as evaluation of PD catheter position, dialysate leaks, encapsulating sclerosing peritonitis, or other intra-abdominal pathologies (hernias, diverticular disease, cholecystitis, etc), the utility of abdominal imaging in patients with PD peritonitis has never been examined.[5,7,9,10] Signs and symptoms of peritonitis may be severe and physicians who

Table 2. Characteristics of Patients With and Without Abdominal Imaging Performed.

	No imaging n=98	Imaging performed n=68	*P* value
Age (years, mean ± SD)	64.2 ± 16.7	65.9 ± 17.6	.53
Male sex (n, %)	47 (48.0%)	30 (44.1%)	.63
Cause of ESKD (n, %)			.24
Diabetes	38 (38.8%)	18 (26.5%)	
Renovascular	4 (4.1%)	10 (14.7%)	
Glomerulonephritis	27 (27.6%)	18 (26.5%)	
Polycystic kidney disease	2 (2.0%)	6 (8.8%)	
Other	27 (27.6%)	16 (23.5%)	
Comorbidities (n, %)			
Diabetes	49 (50.0%)	27 (39.7%)	.19
Coronary artery disease	37 (37.8%)	27 (39.7%)	.80
Peripheral vascular disease	15 (15.3%)	12 (17.6%)	.69
Cerebrovascular disease	10 (10.2%)	10 (14.7%)	.38
Peritonitis organism (n, %)			<.01
Gram positive	51 (52.0%)	17 (25.0%)	
Gram negative	19 (19.4%)	16 (23.5%)	
Polymicrobial	10 (10.2%)	17 (25.0%)	
Fungal	3 (3.1%)	3 (4.4%)	
Fungal with other bacterial organism	1 (1.0%)	6 (8.8%)	
Culture negative	14 (14.3%)	6 (8.8%)	
Mycobacterium	0 (0%)	3 (4.4%)	
Need for hospitalization (n, %)	53 (54.1%)	66 (97.1%)	<.01
Need for ICU admission (n, %)	5 (5.1%)	18 (26.5%)	<.01
Length of admission (days, median [IQR])	7 (4-12)	13 (6-24)	<.01
Need for temporary or permanent HD (n, %)	9 (9.2%)	31 (45.6%)	<.01
Need for catheter removal (n, %)	14 (14.3%)	28 (41.2%)	<.01
Relapsing, recurrent, or refractory peritonitis (n, %)	10 (10.2%)	18 (26.5%)	<.01
Hypotension in ER (n, %)	5 (5.1%)	17 (25.0%)	<.01
Tachycardia in ER (n, %)	15 (15.3%)	22 (32.4%)	<.01
Initial serum lactate (mmol/L, mean ± SD)[a]	2.1 ± 1.1	3.0 ± 2.1	.05

Note. SD = standard deviation; ESKD = end-stage kidney disease; ICU = intensive care unit; IQR = interquartile range; HD = hemodialysis; ER = emergency room.
[a]Serum lactate performed in 102 patients only.

Table 3. Abnormal Abdominal Imaging Findings.

Abnormal findings	Number of patients
Bowel obstruction	8
Intra-abdominal collection or abscess	5
Bile duct dilation with stones	3
Pyelonephritis	2
Splenic infarction	2
Colitis/thickening of bowel wall	2
Bowel ischemia	2
Intra-abdominal hemorrhage	1
Colonic mass	1
Acute diverticulitis with microperforation	1
Abdominal wall hematoma	1
Perforated gallbladder	1
Distended gallbladder	1
Obstructing renal stone	1
Liver mass	1

do not routinely care for PD patients may suspect other causes and thus order potentially unnecessary abdominal imaging.[11] Moreover, the presence of free air under the diaphragm on upright radiography, which suggests a perforated viscus in non-PD patients, may be seen in asymptomatic PD patients. Therefore, this may also lead unexperienced physicians to order potentially unnecessary abdominal imaging.

The result of this study needs to be interpreted in the context of several limitations. First, this was a retrospective study conducted in a single center with a relatively small sample size. Also, the precise indications to perform abdominal imaging could not be elicited from our database and would have helped provide a better clinical picture. Furthermore, it was unclear whether abdominal imaging, when performed, was ordered by nephrologists or other physicians with less experience with PD. The reasoning for the choice of imaging modality could also not be elucidated from our database. All these factors may have introduced a

Table 4. Characteristics of Patients With and Without Abnormal Imaging Findings.

	No abnormalities n=36	Abnormal findings n=32	*P* value
Age (years, mean ± SD)	64.7 ± 19.7	67.3 ± 15.2	.54
Male sex (n, %)	13 (36.1%)	17 (53.1%)	.22
Cause of ESKD (n, %)			.87
Diabetes	10 (27.8%)	8 (25.0%)	
Renovascular	4 (11.1%)	6 (18.8%)	
Glomerulonephritis	11 (30.6%)	7 (21.9%)	
Polycystic kidney disease	3 (8.3%)	3 (9.4%)	
Other	8 (22.2%)	8 (25.0%)	
Comorbidities (n, %)			
Diabetes	12 (33.3%)	15 (46.9%)	.26
Coronary artery disease	15 (41.7%)	12 (37.5%)	.73
Peripheral vascular disease	8 (22.2%)	4 (12.5%)	.29
Cerebrovascular disease	6 (16.7%)	4 (12.5%)	.63
Peritonitis organism			.35
Gram positive	12 (33.3%)	5 (15.6%)	
Gram negative	8 (22.2%)	8 (25.0%)	
Polymicrobial	8 (22.2%)	9 (28.1%)	
Fungal	1 (2.8%)	2 (6.2%)	
Fungal with other bacterial organism	4 (11.1%)	2 (6.2%)	
Culture negative	1 (2.8%)	5 (15.6%)	
Mycobacterium	2 (5.6%)	1 (3.1%)	
Need for hospitalization (n, %)	35 (97.2%)	31 (96.9%)	.93
Need for ICU admission (n, %)	5 (14.3%)	13 (43.3%)	<.01
Length of admission (days, median [IQR])	9 (5-23)	17 (10-36)	.07
Need for temporary or permanent HD (n, %)	11 (30.6%)	20 (62.5%)	<.01
Need for catheter removal (n, %)	11 (30.6%)	17 (53.1%)	.06
Relapsing, recurrent, or refractory peritonitis (n, %)	8 (22.2%)	10 (31.2%)	.40
Hypotension in ER (n, %)	5 (13.9%)	12 (37.5%)	.07
Tachycardia in ER (n, %)	13 (36.1%)	9 (28.1%)	.78
Initial serum lactate (mmol/L, mean ± SD)[a]	2.7 ± 1.8	3.3 ± 2.5	.26
Timing of abdominal imaging (days, mean ± SD)[b]	3 ± 5	3 ± 4	.88

Note. SD = standard deviation; ESKD = end-stage kidney disease; ICU = intensive care unit; IQR = interquartile range; HD = hemodialysis; ER = emergency room.
[a]Serum lactate performed in 102 patients only.
[b]Time from initial hospital presentation to abdominal imaging being performed.

Table 5. Multivariate Analysis Examining Clinical Parameters Associated With Abnormal Imaging Results.

	OR (95% CI)	*P* value
ICU admission	4.37 (1.10-17.42)	.04
Polymicrobial organism	0.90 (0.26-3.08)	.87
Serum lactate (per 1 mmol/L)	1.02 (0.75-1.39)	.89

Note. OR = odds ratio; CI = confidence interval; ICU = intensive care unit.

selection bias. Notwithstanding these limitations, this study is the first to evaluate the utility of abdominal imaging in the setting of PD peritonitis and to identify clinical parameters associated with abnormal imaging findings in a large North American academic PD center.

In conclusion, abdominal imaging should be performed in carefully selected patients with PD peritonitis, especially if there is evidence of hemodynamic instability.

Authors' Note

Presented in part at the University of Missouri Annual Dialysis Conference in Long Beach, Florida, in 2017.

Ethics Approval and Consent to Participate

This study was approved by the Research Ethics Board at the University Health Network.

Consent for Publication

All authors consented to the publication of this article.

Availability of Data and Materials

The data underlying this article will be shared on reasonable request to the corresponding author.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: E.T. receives speaking honoraria from Baxter Healthcare. J.M.B. is a speaker and consultant for Baxter Canada and for DaVita HealthCare Partners.

Funding

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

ORCID iD

Emilie Trinh https://orcid.org/0000-0001-8479-6656

References

1. Perez Fontan M, Rodriguez-Carmona A, Garcia-Naveiro R, Rosales M, Villaverde P, Valdes F. Peritonitis-related mortality in patients undergoing chronic peritoneal dialysis. *Perit Dial Int*. 2005;25(3):274-284.
2. Davenport A. Peritonitis remains the major clinical complication of peritoneal dialysis: the London, UK, peritonitis audit 2002-2003. *Perit Dial Int*. 2009;29(3):297-302.
3. Li PK, Szeto CC, Piraino B, et al. Peritoneal dialysis-related infections recommendations: 2010 update. *Perit Dial Int*. 2010;30(4):393-423.
4. Li PK, Szeto CC, Piraino B, et al. ISPD peritonitis recommendations: 2016 update on prevention and treatment. *Perit Dial Int*. 2016;1036(5):481-508.
5. Stuart S, Booth TC, Cash CJ, et al. Complications of continuous ambulatory peritoneal dialysis. *Radiographics*. 2009;29(2):441-460.
6. De Mauri A, Brambilla M, Chiarinotti D, Matheoud R, Carriero A, De Leo M. Estimated radiation exposure from medical imaging in hemodialysis patients. *J Am Soc Nephrol*. 2011;22(3):571-578.
7. Goldstein M, Carrillo M, Ghai S. Continuous ambulatory peritoneal dialysis-a guide to imaging appearances and complications. *Insights Imaging*. 2013;4(1):85-92.
8. Coyle J, Kinsella S, McCarthy S, et al. Cumulative ionizing radiation exposure in patients with end stage kidney disease: a 6-year retrospective analysis. *Abdom Imaging*. 2012;37(4):632-638.
9. Twardowski ZJ, Tully RJ, Ersoy FF, Dedhia NM. Computerized tomography with and without intraperitoneal contrast for determination of intraabdominal fluid distribution and diagnosis of complications in peritoneal dialysis patients. *ASAIO Trans*. 1990;36(2):95-103.
10. Cochran ST, Do HM, Ronaghi A, Nissenson AR, Kadell BM. Complications of peritoneal dialysis: evaluation with CT peritoneography. *Radiographics*. 1997;17(4):869-878.
11. Trinh E, Saiprasertkit N, Bargman JM. Increased serum lactate in peritoneal dialysis patients presenting with intercurrent illness. *Perit Dial Int*. 2018;38(5):363-365.