

Predictors and Clinical Utility for Positive Abdominal Imaging Findings in Patients Presenting with Peritoneal Dialysis Associated Peritonitis: A Large Regional Health Service Perspective

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ABSTRACT

Introduction: Peritoneal dialysis (PD) associated peritonitis is a common yet serious complication for those undergoing PD. The role of imaging patients presenting with suspected PD peritonitis is unknown. In addition to healthcare costs and patient exposure to ionising radiation, residual kidney function may be at risk with repeated contrast administration. The aim of this study is to understand the indications and ultimate clinical utility of abdominal imaging in patients presenting with PD peritonitis to a large regional health service.

Methods: Retrospective cohort analysis of patients admitted with PD peritonitis to Bendigo Health was conducted. Use and modality of abdominal imaging was recorded. Findings were categorised as positive when congruent with the patient's presenting abdominal pain, or incidental when unrelated. Where imaging was performed, overall influence on patient care was assessed.

Results: There were 53 episodes occurring across 31 patients admitted with PD peritonitis between December 2016 to February 2024. Abdominal imaging was performed in 81% of these episodes (n=43). Positive imaging findings occurred in 31% (n=16), with constipation being frequently identified. Incidental findings occurred in 28% (n=14), while 41% (n=21) showed no abnormalities. No patient or episodic factors were significantly associated with positive imaging findings. Of patients imaged, clinical management was influenced in 21% (n=9) of cases.

Conclusion: Abdominal imaging in suspected PD peritonitis demonstrates low clinical utility, with positive findings directly influencing management in only a minority of cases. There is insufficient evidence to routinely recommend imaging for this cohort.

Keywords: Peritoneal Dialysis, Peritonitis, Diagnostic Imaging

INTRODUCTION

Peritoneal dialysis associated peritonitis (PD peritonitis) is a common yet serious infectious complication that occurs in patients undergoing peritoneal dialysis. It is characterised by abdominal pain, cloudy dialysate with an increase in inflammatory cell count, and often positive PD fluid microcultures¹. The source of infection is usually bacterial, and may occur in the setting of translocation from the bowel (enteric peritonitis, often with constipation but also associated with underlying abdominal pathology), or PD catheter related along with its track through the abdominal wall often due to touch contamination. Culture negative and fungal peritonitis also contribute to the array of causes².

Diagnosis is initially made based on a history of abdominal pain and cloudy PD effluent, along with constitutional symptoms such as fever and lethargy. Whilst PD fluid samples take time to culture, empiric treatment is often initiated in the form of indwelling intra-peritoneal antibiotics. The role for abdominal imaging including computer tomography (CT) and ultrasound (US) in aiding the diagnosis and ruling out other abdominal pathology in PD patients presenting with abdominal pain remains unknown. Currently the International Society for Peritoneal Dialysis (ISPD) does not have clear guidelines on when imaging is suggested³. A recent retrospective analysis by Trinh and Bargman⁴ demonstrated that 41% of patients presenting with PD peritonitis were imaged, of which abnormal findings were identified in 47% of these cases. The most common presenting features that resulted in the perceived need for imaging included ICU admission, polymicrobial or fungal PD cultures, relapsing / refractory / recurrent peritonitis ('R word'), requirement for PD catheter removal, transition to haemodialysis (HD), or symptoms of sepsis. Despite these initial perceived indications for imaging, only ICU admission and need for temporary or permanent haemodialysis was independently associated with positive abdominal findings. How to discern which patients require imaging when presenting clinically with PD peritonitis remains unknown.

Excessive abdominal imaging is deleterious to patients and the healthcare system. In addition to the relative cost of imaging, there is an increased incident cancer risk from CT associated radiation, especially in the setting of abdominal imaging that requires higher doses of radiation for tissue penetration⁵. Furthermore, patients undergoing PD often have some degree of residual kidney function that is imperative to preserve as it not only contributes to dialysis efficiency, but also provides mortality benefit⁶. Whether or not contrast induced or associated nephropathy is prevalent in PD patients remains contentious⁷, however its use is often deferred in non-anuric patients due to the perceived risk of further residual renal function (RRF) loss⁸.

The aim of this study is to understand the perceived indications and ultimate utility of abdominal imaging in patients presenting

with PD peritonitis to a large regional health service (Bendigo Health). This study aims to identify predictive patient and episodic factors for positive abdominal pathology that may be used to guide the decision to pursue abdominal imaging. The secondary aim of this study is to also evaluate the influence positive imaging findings have on patient care. In doing so, this study will hopefully help direct investigations and limit unnecessary and potentially harmful tests.

MATERIALS AND METHODS

A retrospective cohort analysis evaluated all presentations of confirmed PD peritonitis requiring in-patient hospitalisation at Bendigo Health between December 2016 to February 2024. Episodes of confirmed PD peritonitis presenting to the emergency department were identified by review of audit data collected by the Bendigo Home Therapies Department. PD peritonitis was defined in this dataset by ISPD criteria wherein there was at least 2 of: clinically compatible features of PD peritonitis (cloudy dialysis effluent, abdominal pain); elevated dialysis effluent leukocyte count >100 cells/ μ L (with a polymorphonuclear predominance of at least 50%); or positive dialysis effluent microcultures³. Out-patient managed PD peritonitis episodes were excluded from analysis, including those that presented to the emergency department but were subsequently discharged without in-patient admission. Manual screening of individual patient electronic records, pathology, and radiology reports ensued.

Baseline patient characteristics collected included gender, age at presentation, modality of PD (APD vs CAPD), underlying cause for end-stage renal failure (ESRF), and medical comorbidities including previous abdominal surgery. The total number of peritonitis episodes per patient within the study timeframe was also assessed. Refractory (persistent infection despite five days of appropriate antibiotic therapy) or relapsing (recurrence of the same organism after a treated episode within the last four weeks) peritonitis was compared to de novo presentations. Each episode was assessed for length of admission, septic status on presentation, requirement for ICU admission and ICU length of stay. The causative organisms (gram positive, gram negative, culture negative, polymicrobial, or fungal) and peak PD fluid cell counts were also recorded. Furthermore, the necessity for PD catheter removal and transition to HD (interim or permanent) was also noted. Sepsis was defined by the Australian Commission on Safety Quality in Health Care⁹ guidelines, wherein a constellation of vital sign derangement, clinical or pathological signs of hypoperfusion, or altered mentation were present.

The utilisation of abdominal imaging including CT, X-ray, and ultrasound was assessed. We included all abdominal imaging performed at any point during in-patient admission that aimed to either aid in the diagnosis of PD peritonitis and assess for complications thereof, as well as imaging used to rule out alternative pathology. Use of contrast media (intravenous or oral) for CT was also recorded. Indications for imaging were assessed

by review of imaging request forms and review of clinical documentation.

Imaging was classified as having ‘positive findings’ when the results were congruent to the patient’s presentation of abdominal pain (including acute surgical pathologies and constipation). Negative findings were defined as no abnormalities seen on scan. Incidental findings were defined as abnormalities present that could not explain or be linked to the presentation of PD peritonitis (e.g. adrenal incidentalomas, subacute biliary pathology). Each baseline patient characteristic and episode features were assessed for correlation with positive findings to determine who may benefit from imaging.

Where positive imaging findings were present, overall influence on patient management was also assessed by ensuing changes in patient care. Analysis of imaging for negative predictive value of surgical pathologies was not assessed.

Ethical approval

This study was approved by the Bendigo Health division of the Victorian Human Research Ethics Committee (LRSSA/107914/BH-2024-461091(v3)).

Statistical Analysis

Categorical variables were summarised using counts (n) and percentages, and continuous variables were described using mean $\pm$ standard deviation or median with interquartile range, as appropriate. Associations between patient factors, clinical features, and positive imaging outcomes were initially assessed using Fisher’s exact test for categorical variables, or a Student’s t test for continuous variables. Variables showing a significant association on univariable screening were subsequently entered into univariable binary logistic regression models to derive odds ratios (OR) and corresponding 95% confidence intervals (CI) quantifying the strength of association. For one variable (past history of diabetic nephropathy), a zero-cell count in the 2x2 contingency table precluded standard logistic regression due to complete separation; Firth’s penalized logistic regression was therefore used instead, with significance assessed via the penalized likelihood ratio test. Statistical significance was defined as a two-tailed p-value <0.05 . Analyses were performed using GraphPad Prism (version 10.6.1) and Python (version 3.14).

RESULTS

A total of 54 patient episodes occurred across 31 patients between December 2016 to February 2024. One patient episode was excluded from review as they presented to the emergency department but were subsequently managed as an out-patient without the need for admission. The baseline characteristics of these patients can be found in Table 1. The median length of stay was 4 nights. ICU admission occurred less frequently (5) with a median ICU length of stay of 5 nights. Sepsis was relatively uncommon (6 vs 47) and seven patients required removal of their

PD catheters during admission with transition to haemodialysis (either temporary or permanently).

Table 1: Baseline and Episode Factors of Patients Presenting with PD Peritonitis

Patient baseline factors	
Age, years (mean $\pm$ SD)	62.5 $\pm$ 12.3
M: F (n)	36:17
Number of episodes per patient within study timeframe (n)	
1	18
2	8
3	2
4	2
5	1
Mean	2.3
APD: CAPD (n)	40:13
Underlying cause for ESRF (n)	
Diabetic nephropathy	12
Renovascular	11
Glomerulonephritis	11
Polycystic Kidney Disease	8
Obstructive nephropathy	3
Genetic	1
Multifactorial	7
Comorbidities (n, %)	
Hypertension	38 (72%)
Diabetes mellitus (all)	27 (51%)
Congestive cardiac failure	19 (36%)
Dyslipidaemia	18 (34%)
Ischaemic heart disease	16 (30%)
Atrial fibrillation	14 (26%)
Chronic obstructive pulmonary disease	10 (19%)
Cancer (all)	4 (8%)
Previous abdominal surgery (n, %)	7 (13%)
Patient episode factors	
Admission nights of stay (median, IQR)	4 [3–7]
Septic during presentation (n, %)	6 (11%)
Admitted to ICU (n, %)	5 (9%)

Patient episode factors	
Peak PD fluid cell count (n x 10 ⁶ /L), median, IQR	3010 [1470-8190]
PD Culture organism (n, %)	
Gram positive	15 (28%)
Gram negative	10 (19%)
Culture negative	17 (32%)
Polymicrobial	5 (9%)
Fungal	0
Relapsing or recurrent infection (n, %)	5 (9%)
PD catheter removed during admission (n, %)	7 (13%)

Abdominal imaging was performed in 81% of episodes (n=43), of which CT occurred in 68% (n=36), X-ray in 15% (n=8), and ultrasound in 13% (n=7); a total of 51 scans. Of patients that had a CT scan, 39% (n= 10) had intravenous contrast delivery. No patients received oral contrast. Seven patients had multiple imaging modalities performed during their presentation. The suspected disease specified indications for imaging included diverticulitis (n=4), bowel perforation (n=4), constipation (n=3), bowel obstruction (n=3), PD catheter collection (n=3), and specified two or more surgical pathologies (n=12). No disease specified indication for imaging including 'to rule out alternate cause' made up 14 (33%) of imaging requests.

Positive imaging findings pertaining to the patient's presentation occurred in 31% (n=16) of studies. Incidental findings were found in 28% (n=14), and no abnormalities were seen in 41% (n=21) of scans performed. Incidental findings included diverticulosis without diverticulitis, adrenal lesions, subacute biliary pathology (e.g. porcelain gallbladder), and basal pneumonias/pleural effusions.

Of the patients that underwent CT, 28% (n=10) had positive findings pertaining to their presentation, 39% (n=14) had incidental findings that did not pertain to their presentation, and the remaining 33% (n=12) had no abnormalities detected. Of the positive findings related to the presentation of PD peritonitis constipation/faecal loading was found commonly (n=4), whilst acute surgical pathology such as diverticulitis (n=2), bowel perforation (n=2), biliary pathology (n=1), and intraabdominal collections (n=1) made up the remainder.

Abdominal X-ray identified constipation/faecal loading in three scans, with no abnormalities detected in the other five. No bowel obstruction or perforations were detected. Ultrasound demonstrated acute biliary pathology in three cases and no abnormalities in the remaining four scans. No PD catheter collections were detected.

Past history of ischaemic heart disease appeared predictive for positive findings (OR 4.80, 95CI 1.16 to 19.93, P = 0.04), whilst

a history of hypertension appeared protective (OR 0.21, 95CI 0.05 to 0.87, P = 0.04), although confidence intervals were broad. Diabetic nephropathy also appeared protective, with Firth's penalized logistic regression corroborating the Fisher's exact test finding (OR = 0.09, P = 0.02 by penalized likelihood ratio test), although the 95% confidence interval was broad (0.004–1.94) reflecting the small sample size. No other patient factors were significantly associated with an increased likelihood of positive imaging findings (see Table 2). No episodic features were more likely to result in positive imaging findings.

Of patients that had imaging performed, clinical management was determined to be influenced in 21% (n=9) of cases. Review by the general surgical team was sought in 7/9 cases, antibiotics directed to diverticulitis in 1/9 cases, and aperients were administered in 1/9 cases where they had previously not been empirically prescribed. Of the surgical reviews 4/7 were determined not to have any acute surgical pathology clinically and thus did not require an operative or change to their current management. Two patients were taken for operations (drainage of abdominal collections, cholecystectomy), and one patient was managed for cholecystitis conservatively given their frailty and non-suitability for an operation.

DISCUSSION

Abdominal imaging was frequently performed in patients presenting with PD peritonitis, with over 80% of patient episodes involving at least one form of imaging. CT was the most common modality (n= 36, 68%), whereas abdominal X-ray and ultrasound were less frequently utilised (15% and 13%, respectively). Around one-third of CT scans included intravenous contrast.

The overall diagnostic yield from imaging in this cohort was modest. Positive findings directly related to the patient's presentation were present in 31% of studies, while incidental findings accounted for 28%, and no abnormalities seen in 41%. Positive results were notably lower than the 47% reported by Trinh and Bargman⁴ study, which may reflect differences in patient populations or thresholds for imaging between cohorts. Additionally, we included constipation as a pertinent finding on imaging, as it was frequently identified, comprising 40% of positive CT findings, and 38% of positive abdominal X-ray findings. Given that constipation is both common in patients undergoing PD, and a known risk factor for PD-associated peritonitis, its recognition and management is highly relevant¹¹. However, whether imaging is truly required to make this diagnosis is debatable, as it is often clinically suspected and may be empirically managed without confirmational imaging¹². This highlights a potential area for more judicious imaging use, reserving scans for cases where surgical pathology or diagnostic uncertainty exists.

No baseline patient factors - including age, comorbidities, cause of ESRF, PD modality, or previous abdominal surgery - were significantly associated with positive findings. Similarly, no

Table 2: Patient Baseline and Episode Factors and Relation to Imaging Findings

Factor	Positive findings	Negative findings	Not imaged	P value
Male sex, n	8	23	5	0.16
Age, years (mean +/- STD)	61.5 (12.9)	62.7 (11.1)	-	0.78^
Septic status (n)	2	2	1	0.59
Admitted to ICU (n)	1	3	1	1
Previous abdominal surgical history (excludes PD catheter insertion) (n)	4	2	3	0.08
Admission length days (mean +/- STD)	5.14 (2.9)	6.62 (6.4)	-	0.42^
Cause of ESRF (n)				
Polycystic kidney disease	4	2	2	0.08
Diabetic nephropathy	0	8	4	0.04
Renovascular	4	6	1	0.70
Glomerulonephritis	1	10	0	0.07
Obstructive nephropathy	2	0	1	0.10
Diabetes (all)	5	16	6	0.33
Multifactorial	3	2	2	0.31
Genetic	0	1	0	1
Medical comorbidities (n)				
Atrial fibrillation	5	8	1	0.73
Hypertension	7	24	7	0.04
Congestive cardiac failure	6	9	4	0.76
Ischaemic heart disease	7	5	4	0.04
Chronic obstructive pulmonary disease	2	4	4	1
Cancer (all)	0	2	2	1
Dyslipidaemia	3	11	4	0.11
Diabetes (all)	5	16	6	0.33
Cell count (mean ± SD)	8841 ± 16434	9075 ± 13537	-	0.96^
PD fluid microculture (n)				
Gram positive	5	10	5	1
Gram negative	4	5	1	0.45
Culture negative	3	10	4	0.29
Polymicrobial	2	3	0	1
Two or more episodes (n)	9	10	2	0.14
APD (n)	10	21	9	1
Relapse or recurrence (n)	1	4	0	1
PD catheter removed (n)	2	5	0	1
Defined indication for imaging (n)	10	19	24	0.28

P values are for Fisher's exact test for categorical data unless delineated by '^' for p values for unpaired Student t test for continuous data.

episode related factors such as length of stay, PD culture organism and cell count, need for ICU, or transition to HD correlated with positive findings. This suggests that decision-making should remain driven by clinical presentation and indication, rather than relying on demographic or disease-related predictors.

The influence of imaging on patient management was limited, altering care in approximately one in five cases. Surgical review was the most common outcome, though in more than half of these cases no intervention was required. Antibiotics were directed to diverticulitis in one case, and aperients prescribed in another where they had not been empirically initiated. While these represent clinically meaningful changes, the overall proportion highlights that imaging often did not materially alter management, consistent with the uncertainty around its role as detailed in current ISPD guidelines³.

Our findings build upon existing literature by demonstrating that abdominal imaging is frequently performed in PD-associated peritonitis but often identifies incidental findings or diagnoses that may not require imaging to confirm, such as constipation. Furthermore, it appears that the overall yield once positive findings are found remains low, as management is often unchanged. This further supports a more selective, indication-driven approach, balancing diagnostic yield with the risks of radiation, contrast exposure, and healthcare costs.

The main limitation of this study is its modest sample size, which reduces power to detect significant associations that may limit generalisability. What this study does add is the perspective of perceived indications for imaging in this cohort (often to 'rule out' pathology / negative predictive value), and the ultimate utility in doing so. Further multicentre work is required to guide evidence-based imaging recommendations in suspected PD peritonitis.

CONCLUSION

Abdominal imaging in patients with PD peritonitis demonstrated relatively low clinical utility, with positive findings directly influencing management in only a minority of cases. The frequent identification of incidental findings and diagnoses such as constipation - often clinically suspected without imaging - suggests that scans may contribute more to healthcare costs and patient risk than to meaningful changes in care.

This study remains uncertain as to whether any patient factors, presenting features, or pre-test characteristics are predictive for positive imaging findings. Larger, multicentre studies are required to determine whether such predictive factors exist and to better define which patients may benefit from abdominal imaging, thereby guiding more judicious and cost-effective use. In PD peritonitis, abdominal imaging should be reserved for cases with clear clinical indication, as routine use offers limited benefit while exposing patients to unnecessary risks and healthcare costs.

DISCLOSURES/CONFLICTS OF INTEREST

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Ethical considerations: This study was approved by the Bendigo Health division of the Victorian Human Research Ethics Committee (LRSSA/107914/BH-2024-461091(v3)). Consent to participate was waived by the Victorian Human Research Ethics Committee in this deidentified cohort analysis as the project was determined to be 'Low and Negligible Risk'.

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Data accessibility in a de-identified format is available upon request to the listed authors.

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