Periprocedural Peritonitis Prophylaxis: A Summary of the Microbiology and the Role of Systemic Antimicrobials

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Keywords

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Abstract

Background: Peritonitis is a leading complication of peritoneal dialysis (PD). One strategy that the International Society for Peritoneal Dialysis (ISPD) has used to help mitigate the morbidity and mortality associated with peritonitis is through prevention, including antibiotic prophylaxis utilization in high-risk situations. The aim of this study is to summarize our current understanding of postprocedural peritonitis and discuss the existing data behind periprocedural antibiotic prophylaxis, focusing primarily on PD catheter insertion, dental procedures, colonoscopies, upper endoscopies with gastrostomy, and gynecologic procedures. **Summary:** The ISPD currently recommends intravenous antibiotics prior to PD catheter insertion, colonoscopies, and invasive gynecologic procedures, though prophylaxis has only demonstrated benefit in a prospective, randomized control setting for PD catheter insertion. However, multiple retrospective studies exist that support the use of antibiotic prophylaxis for the other 2 procedures. No specific antibiotic regimen has been established as most optimal to prevent

peritonitis for any of the 3 procedures. Antibiotic coverage should include the Enterobacteriaceae family, as well as Gram-positive organisms commonly found on the skin flora for PD catheter insertion, anaerobes for colonoscopies, and common organisms from the urogenital flora in gynecologic procedures. Additionally, the ISPD currently recommends oral amoxicillin prior to dental procedures. There is currently no ISPD recommendation to provide antibiotic prophylaxis prior to an upper endoscopy with or without gastrostomy, though this is a potential area for research. **Key Messages:** PD patients are at high risk for developing peritonitis after typical procedures. Antibiotic prophylaxis is a potential strategy that the ISPD utilizes to prevent these infections. However, further research needs to be done to determine the optimal antibiotic regimen.

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Introduction

Peritonitis is a leading complication of peritoneal dialysis (PD) [1]. Peritonitis is associated with higher rates of conversion from PD to hemodialysis and mortality in the PD population [1]. End-stage kidney disease (ESKD)

patients are already inherently at high risk for infections and sepsis-related mortality due to the effects of uremia on both innate and adaptive immunity [2]. Additionally, PD patients are at a high risk for peritonitis due to the presence of a long-term catheter in the peritoneal cavity [3]. One strategy that the International Society for Peritoneal Dialysis (ISPD) has used to help mitigate the morbidity and mortality associated with peritonitis is through prevention, including antibiotic prophylaxis utilization in high-risk situations [4]. However, there is great inter-facility variability with regard to adherence to ISPD guidelines on antibiotic prophylaxis strategies [5]. The aim of this study is to summarize our current understanding of postprocedural peritonitis and discuss the existing data behind periprocedural antibiotic prophylaxis. We will focus on the procedures with the most published evidence, particularly PD catheter insertion, dental procedures, colonoscopies, upper endoscopies with gastrostomy, and gynecologic procedures.

PD Catheter Insertion

Exit site infections (ESIs) are a common cause of subsequent peritonitis in the PD population, with about 12% of cases of ESI progressing to peritonitis [3]. The majority of organisms cultured from ESIs are Gram positives commonly found on the skin, such as *Staphylococcus aureus*, coagulase-negative *Staphylococcus* spp., and *Streptococcus* spp. [6–8]. In one particular study of obese PD patients, Nessim et al. [7] found that these Gram positives made up 79% of ESIs but 55% of peritonitis, while Gram negatives made up only 7% of ESIs but 25% of peritonitis. Additionally, in an Italian study of 102 ESIs conducted in 1991 by Scalapomagna et al. [6], *S. aureus* and Gram-negative infections were the only organisms that led to PD catheter removal. The most common Gram negatives that Scalapomagna et al. [6] isolated were *Pseudomonas aeruginosa*, which made up 7.8% of cases, and *Escherichia coli*, which made up 3.9% of cases. Nessim et al. [7] did not report the specific Gram negatives that were cultured. Anaerobes seem to be infrequent causes of peritonitis from ESIs, making up only 0.7% of cases in a Canadian study published in 2010 by Hildebrand et al. [8] comparing First Nation and non-First Nation individuals. Given the high prevalence of Gram-positive ESIs and the high rates of peritonitis and subsequent complications from Gram-negative ESIs, potential regimens for prophylaxis likely should cover Gram positives from the skin, as well as those from the Enterobacteriaceae family.

The ISPD currently recommends multiple strategies to prevent ESI, especially during the catheter insertion, with the hope that preventing ESIs will decrease the risk of peritonitis. Of particular interest to this review is the grade 1A recommendation from the 2016 ISPD guidelines to administer systemic antibiotics prior to catheter insertion, though a specific antibiotic regimen is not listed [4]. This recommendation is based on 4 randomized controlled trials comparing perioperative IV antibiotics with no antibiotics and the resulting systematic review of these studies [9]. Lye et al. [10] found in a study of 50 patients no benefit from giving intravenous (IV) cefazolin and gentamicin prior to PD catheter insertion. However, the other 3 studies demonstrated a positive result when comparing antibiotics head-to-head with no antibiotics. They were conducted by Bennett-Jones et al., who examined in 27 patients IV gentamicin versus no antibiotics, Wikdahl et al. [12] who studied in 38 patients the combination of IV cefuroxime preoperatively and intraperitoneal cefuroxime perioperatively versus no antibiotics, and Gadallah et al. [11] who compared IV vancomycin with both IV cefazolin and no antibiotics in 221 patients undergoing 254 PD catheter placements [11–13]. Interestingly, Gadallah et al. [11] found that vancomycin did better than cefazolin in preventing peritonitis, even though vancomycin lacks the Gram-negative coverage that is present from cefazolin. This observation can potentially be explained by the fact that of the 17 patients that suffered peritonitis after PD catheter insertion in the study, only 4 cases were not from a Gram-positive organism; 3 were culture negative; and 1 was due to *Enterobacter cloacae* [11]. Overall, based on these 4 trials, it appears that systemic antibiotics perioperatively likely would provide benefit during PD catheter insertions, though further research has to be conducted to identify the most appropriate regimen.

Once the PD catheter is inserted, there is debate about the optimal time to initiate PD, though it appears there are higher rates of peritoneal fluid leaks when PD is initiated at 1 week from catheter insertion compared to waiting 2–3 weeks based on the Timely PD study [14, 15]. Leaks are associated with ESIs and peritonitis [16]. In one retrospective review of 79 leaks in 66 patients, Holley et al. [17] found that 42% of leaks were associated with some form of infection either before or after a leak was observed, and even with prophylactic antibiotics, 11 of the 66 patients developed a postleak infection. Given the high risk for infection, leaks should be avoided, and if present, antibiotics should probably be given prophylactically while an infectious workup is completed to rule out peritonitis or ESI.

Dental Procedures

The ESKD population has severe oral disease compared to the general population, which can result in systemic consequences [18]. A multinational collaboration of investigators prospectively enrolled 4,726 hemodialysis patients between 2010 and 2012 into the ORAL-D cohort study and found that edentulousness, tooth decay, missing teeth, and filled teeth are associated with a higher rate of early death [19]. However, it is difficult to determine if this correlative relationship has more to do with the fact that dental disease is associated with lower socioeconomic status, reduced receptiveness to healthcare engagement, and lower health literacy, which, in turn, are linked to mortality [20, 21]. When propensity matched, there does not appear to be a link between periodontitis and both all-cause mortality and cardiovascular mortality [22]. Regular visits to a dental practitioner are a potential method for intervening on the poor oral care seen in ESKD patients.

Dental procedures, however, are not without their own risks. Dental procedures are associated with both transient bacteremia and endocarditis, likely from the tissue trauma that open up small blood vessels to bacterial entry [23]. In the PD population, this bacteremia can lead to peritonitis. *Streptococcus* spp. are the most common organisms cultured from odontogenic bacteremic patients after dental procedure [24]. In particular, *Streptococcus viridans* is the predominant organism seen in PD patients with postdental procedure peritonitis [25–27].

Patients with high risk for endocarditis, like those with prosthetic heart valves or unrepaired congenital cyanotic diseases, are well known to require antibiotic prophylaxis prior to dental procedures. One dose of amoxicillin 2 g, or clindamycin 600 mg for penicillin-allergic patients, is given for prophylaxis 30–60 min prior to a dental procedure in these patients [28]. PD patients are a lesser known population that should receive antibiotic prophylaxis to prevent peritonitis associated with the transient bacteremia from dental procedures [4]. In fact, in a survey completed in 2004 with nephrologists in Australia and New Zealand, only 41% of respondents recommended antibiotic prophylaxis for dental procedures [29]. ISPD guidelines from 2016 suggest using a single oral dose of amoxicillin as the prophylaxis regimen, similar to that used in the patients at high risk for endocarditis, as described above, though data are limited to support this recommendation [4]. The American Dental Association currently has no specific guidelines for antibiotic prophylaxis in PD patients. However, given the high morbidity and mortal-

ity associated with peritonitis and the relatively low risk of a single dose of amoxicillin, providers should recommend antibiotic prophylaxis in PD patients undergoing dental procedures.

Colonoscopy

As a part of the American Board of Internal Medicine's Choosing Wisely campaign and in accordance with the American College of Physicians' recommendation against screening in patients with life expectancies of <10 years, the American Society of Nephrology generally does not recommend colorectal cancer screening in ESKD patients on maintenance dialysis due to their limited life expectancies once they reach the age of 50 [30]. However, colonoscopies are still a common procedure both in the inpatient and outpatient setting, especially given the higher rates of gastrointestinal bleeding in ESKD patients compared to the general population [31]. Kidney transplant candidates, in particular, continue to be screened for colorectal cancer as well, a disproportionate percentage of whom are on PD as a dialysis modality [30]. There is growing literature that colonoscopy increases the risk of peritonitis in the PD population [32–34]. Mucosal disruption and subsequent seeding of the peritoneum is the most frequently proposed mechanism [25, 32]. The rate of peritonitis after colonoscopies without antibiotic prophylaxis in PD patients has been reported to be between 4 and 8% [32–34]. Colonic biopsies do not appear to increase the risk for peritonitis any further, but there have been conflicting data about whether polypectomies increase this risk [32–34]. As it is not possible to determine which patients will undergo polypectomies during their colonoscopy, all patients are treated as if they will undergo a polypectomy.

The most frequent culprit organisms cultured from the peritoneal fluid are from the Enterobacteriaceae family, especially *E. coli* (shown in Table 1; online suppl. Table 1; see www.karger.com/doi/10.1159/000513773 for all online suppl. material). Treatment most commonly includes a first-generation cephalosporin plus an aminoglycoside, which is an ISPD guideline-recommended empiric antibiotic regimen for peritonitis [4, 32]. However, there are cases of other organisms from the gut flora, particularly anaerobes, like *Bacteroides* spp., that would not be covered by this empiric therapy [35]. In patients who do not improve with ISPD guideline-directed antibiotic therapy for peritonitis, providers should consider expanding antibiotic coverage to include anaerobes.

Table 1. Summary of published cases of peritonitis in PD patients after colonoscopy

PMID	Pu- blished year	Age	Sex	Additional endoscopic procedures	Prophylaxis	Culture	Treatment	Prognosis
2085593	1990	65	F	Polypectomy	Vancomycin + gentamicin	Nonfragilis <i>Bacteroides</i> spp.	Gentamicin + metronidazole	Survived
28708216	2017	nr	nr	nr	Ceftazidime	<i>E. coli</i> , <i>Enterobacter</i> spp.	Antibiotics	Survived
28708216	2017	nr	nr	nr	Ceftazidime	<i>Candida albicans</i>	Antifungals PD catheter removal	Survived
28708216	2017	nr	nr	nr	Ceftazidime	<i>Klebsiella</i> spp.	Antibiotics	Survived
3101488	1987	69	M	None	None	<i>E. coli</i>	Clindamycin	Survived
3653661	1987	65	M	Polypectomy	None	<i>E. coli</i>	Cephalothin	Survived
7927824	1994	51	F	Polypectomy	None	<i>Peptostreptococcus asaccharolyticus</i> , <i>Bacteroides disiens</i> , <i>Bacteroides</i> <i>ureolyticus</i>	Cefuroxime + metronidazole	Survived
17704448	2007	nr	F	None	None	3 no growth, 1 coagulase-negative <i>Staphylococcus</i> , 1 <i>E. coli</i> (authors combined the culture results)	Antibiotics	Survived
17704448	2007	nr	F	None	None		Antibiotics	Survived
17704448	2007	nr	F	None	None		Antibiotics	Survived
17704448	2007	nr	F	Colonic biopsy	None		Antibiotics	Survived
17704448	2007	nr	F	Colonic biopsy, polypectomy	None		Antibiotics	Survived
20919445	2010	67	F	Polypectomy	None	<i>E. coli</i>	Ceftazidime	Survived
20919445	2010	73	M	Polypectomy	None	<i>E. coli</i> , <i>Klebsiella oxytoca</i> , <i>Enterococcaceae</i> spp.	Vancomycin + gentamicin	Survived
22821097	2012	53	F	Polypectomy	None	<i>E. coli</i> , <i>Klebsiella pneumoniae</i> , <i>Enterococcus faecalis</i>	Cefazolin + ampicillin	Survived
23936514	2013	nr	nr	Polypectomy	None	<i>E. coli</i> , <i>Klebsiella pneumoniae</i> , <i>Enterococcus faecalis</i>	nr	nr
23936514	2013	nr	nr	Polypectomy	None	No growth	nr	nr
28100993	2016	57	F	Upper endoscopy	None	<i>Candida tropicalis</i>	Fluconazole, PD catheter removal	Survived
28708216	2017	nr	nr	nr	None	<i>E. coli</i>	Antibiotics	Survived
28708216	2017	nr	nr	nr	None	<i>Klebsiella</i> spp.	Antibiotics	Survived
28708216	2017	nr	nr	nr	None	No growth	Antibiotics	Survived
28708216	2017	nr	nr	nr	None	<i>Enterobacter</i> spp.	Antibiotics	Survived
31694579	2019	70–80	F	None	None	<i>S. aureus</i>	Cefazolin + gentamycin, PD catheter removal	Survived
31694579	2019	20–30	F	Colon biopsy	None	No growth	Cefazolin + gentamycin	Survived
31694579	2019	60–70	F	Colon biopsy	None	<i>E. coli</i>	Ceftazidime + metronidazole	Survived
31694579	2019	30–40	M	Endoscopic mucosal resection	None	No growth	Cefazolin + gentamycin	Survived
31694579	2019	40–50	M	Endoscopic mucosal resection	None	<i>E. coli</i>	Cefamezin + tobramycin	Survived
31694579	2019	50–60	F	Endoscopic mucosal resection	None	No growth	Cefamezin + gentamycin	Survived
31694579	2019	50–60	M	Endoscopic mucosal resection	None	<i>E. coli</i>	Cefamezin + gentamycin	Survived
31694579	2019	30–40	M	Polypectomy	None	<i>E. coli</i>	Vancomycin + ceftazidime	Survived
31694579	2019	60–70	M	Polypectomy	None	<i>E. coli</i>	Cefazolin + gentamycin	Survived

Listed treatments were the final antibiotics selected after the result of culture data. “Antibiotics” were listed for treatment if the authors did not specify the name of the antibiotic chosen. References are listed in the online suppl. material. PD, peritoneal dialysis; nr, not reported.

Additionally, there are rare cases of fungal peritonitis associated with colonoscopies, which also would not be covered by the above empiric therapy and would portend to a higher mortality rate [25, 36]. Due to the high morbidity and mortality associated with fungal infections, the ISPD does recommend either oral nystatin or oral fluconazole for prophylaxis in patients who are exposed to a prolonged course of antibiotics, which is a known risk factor for developing fungal peritonitis, irrespective of whether or not there is a planned procedure [4, 25]. Colonoscopies are not a known independent risk factor for fungal peritonitis. However, fungal peritonitis has to be considered, as well, if patients do not improve with the above ISPD guideline-directed antibiotic therapy for peritonitis, especially if they recently underwent antibiotic therapy for another bacterial infection.

With regard to prevention, there is one known published randomized control study of 93 PD patients performed by Al-Hwiesh et al. [34] who found no benefit for the use of only ceftazidime for prophylaxis prior to colonoscopy. However, ceftazidime lacks coverage for anaerobic organisms that can be seen in pericolonoscopy peritonitis, as well as for many Gram positives [37].

There are 3 other retrospective studies that compared the rates of peritonitis in patients who received pericolonoscopy antibiotics with patients who did not. Yip et al. [33] reviewed 97 colonoscopies in 77 PD patients and found 5 cases of postprocedure peritonitis, none of which were the 18 cases who received some form of periprocedure antibiotics. Gweon et al. [32] also retrospectively observed that none of their 65 PD patients who received prophylactic antibiotics developed peritonitis after colonoscopy, compared to 9 who suffered from peritonitis out of the 172 patients who did not receive prophylactic antibiotics. Both retrospective observations were not statistically significant, likely due to their small sample sizes. Lastly, in a retrospective study of all gastrointestinal and gynecologic endoscopies, Wu et al. [38] found a statistical significance in reducing peritonitis rates in patients who received prophylactic antibiotics prior to nonesophagogastroduodenoscopy endoscopies, including colonoscopies. All 3 retrospective studies suggest that utilizing pericolonoscopy antibiotics has the potential to prevent postprocedural peritonitis.

However, the specific antibiotic regimen in these studies was quite heterogeneous. Gweon et al. [32] did not report the specific periprocedure antibiotics that were used, but Yip et al. [33] reported 14 different antibiotic regimens among the 18 cases who received antibiotics prior to a colonoscopy, 6 of which received cephalosporin

monoprophylaxis, 5 of which received an aminoglycoside as a part of their regimen, and 4 of which received levofloxacin [32, 33]. Among the 4 patients who received levofloxacin, 3 received the antibiotic by itself while another received it as a part of tuberculosis treatment [32, 33]. On the other hand, Wu et al. [38] reported that among the 5 patients who received antibiotics prior to their colonoscopy, 3 got a dose of ceftriaxone [38].

Nonetheless, in response to the increased risk of peritonitis after colonoscopy, the ISPD recommends prophylactic antibiotics for any PD patient prior to undergoing a colonoscopy [4]. This 2016 guideline does not recommend a specific antibiotic choice but cites a single dose of IV ampicillin plus an aminoglycoside, with or without metronidazole, as a potential regimen, citing a previous systematic review, although it should be noted that this systematic review did not specifically mention or suggest this regimen [4, 9]. This prophylactic regimen would generally cover the organisms described above that most commonly cause peritonitis. Additionally, the abdomen should be empty of fluid prior to the procedure [25, 39]. Citing a 2011 ISPD position paper, the 2015 American Society for Gastrointestinal Endoscopy (ASGE) guidelines also recommend prophylactic antibiotics prior to a colonoscopy in PD patients but do not suggest any specific regimen [40].

The recommendations developed in conjunction between the American Society of Health-System Pharmacists (ASHP), the Infectious Diseases Society of America (IDSA), the Surgical Infection Society (SIS), and the Society for Healthcare Epidemiology of America (SHEA) in 2013 for antibiotic prophylaxis prior to colorectal surgery may also provide guidance on the appropriate antibiotic regimen prior to a colonoscopy. Citing a Cochrane systematic review of 182 studies in 2009 that has since been updated to 260 trials in 2014, these guidelines recommend using an antibiotic regimen with activity against anaerobic and aerobic floras of the bowel prior to colorectal surgery, such as cefazolin plus metronidazole, cefoxitin, cefotetan, ampicillin-sulbactam, or ceftriaxone plus metronidazole in regions with high Gram-negative resistance to first- and second-generation cephalosporins [41, 42]. Similar to postcolonoscopy peritonitis, the most common culprit organisms seen in infections after colorectal surgery are *E. coli* and anaerobes, like *Bacteroides fragilis* [43]. Given the similar bacteriology, this guideline has potential applications to determining an appropriate antibiotic regimen prior to colonoscopies in PD patients.

Table 2. Summary of published cases of peritonitis in PD patients after upper endoscopy

PMID	Published year	Age	Sex	Additional endoscopic procedures	Prophylaxis	Culture	Treatment	Prognosis
11510264	2001	66	F	PEG placement	None	<i>Candida</i> spp.	nr	Deceased
11510264	2001	37	M	PEG placement	None	<i>Klebsiella</i> spp.	Antibiotics	Survived
11510264	2001	81	F	PEG placement	None	nr	Antibiotics	Survived
11510264	2001	64	M	PEG placement	None	<i>Candida</i> spp.	nr	Deceased
11510264	2001	58	M	PEG placement	None	Polymicrobial including fungal	nr	Deceased
16686285	2005	69	M	Epinephrine injection, heat-probe coagulation of a bleeding ulcer	None	<i>Streptococcus viridans</i>	Ceftazidime, clarithromycin	Survived
21084055	2010	49	F	None	None	<i>Enterococcus faecalis</i>	Imipenem/cilastatin + vancomycin	Survived
23936514	2013	nr	nr	Local hemostasis	None	<i>E. coli</i>	nr	nr
25228218	2014	28	M	None	None	<i>Klebsiella pneumoniae</i> , <i>Morganella morganii</i> , <i>Bacteroides fragilis</i> , <i>Prevotella</i> spp., <i>Clostridium clostridioforme</i> , <i>Citrobacter koseri</i> , <i>Enterococcus faecium</i>	Vancomycin + tobramycin + metronidazole, PD catheter removal	Deceased
25228218	2014	73	M	Epinephrine injection, placement of multiple clips	None	<i>E. coli</i>	Ciprofloxacin	Survived
26483616	2015	50	M	Duodenal ulcer biopsy, colonoscopy	None	Coagulase-negative <i>Staphylococcus</i>	Vancomycin + cefepime	Survived
28100993	2016	57	F	Colonoscopy	None	<i>Candida tropicalis</i>	Fluconazole, PD catheter removal	Survived

Listed treatments were the final antibiotics selected after the result of culture data. “Antibiotics” were listed for treatment if the authors did not specify the name of the antibiotic chosen. References are listed in the online suppl. material. PD, peritoneal dialysis; nr, not reported; PEG, percutaneous endoscopic gastrostomy.

Upper Endoscopy with Gastrostomy

There currently is little data to support the benefit of prophylactic antibiotics in upper endoscopies alone compared with colonoscopies. In fact, the ISPD 2016 guidelines do not recommend the use of antibiotic prophylaxis prior to an upper endoscopy [4, 25]. Additionally, Wu et al. [38] in 2013 found that upper endoscopies had significantly lower rates of peritonitis compared to other types of endoscopic procedures in PD patients [38].

However, there is growing literature that demonstrates a relationship between percutaneous endoscopic gastrostomy (PEG) placement and postprocedure peritonitis in PD patients [44]. Given that malnutrition is a known risk factor for mortality in the ESKD population, PEG placements may start to become more common, especially in younger individuals on PD who need to be bridged to a kidney transplant [45]. The mechanism for developing peritonitis in upper endoscopies with PEG placements is likely similar to that for colonoscopies given the significant amount of air insufflation and the

puncturing of the abdominal wall required for PEG placements [46]. Interestingly, the risk of peritonitis is not present in PD patients who received their PEG prior to initiating PD [44].

Organisms commonly cultured in the peritoneal fluid after PEG placement are similar to those found after colonoscopy (shown in Table 2; online suppl. Table 2). Additionally, fungal peritonitis is a rare occurrence after PEG placement [47]. There have also been case reports of peritonitis with cultures positive for oral flora like *Streptococcus viridans* [48, 49]. Fortunately, oral flora, like *Streptococcus viridans*, tends to be susceptible to the ISPD-recommended empiric therapy for peritonitis. Nevertheless, the literature continues to be sparse about the presence of a benefit to antibiotic prophylaxis prior to an upper endoscopy with or without a PEG placement, and the ISPD 2016 guidelines do not specify using antibiotic prophylaxis in the setting of an upper endoscopy [4, 38]. The 2015 ASGE guidelines, however, do recommend administering cefazolin prior to an upper endoscopy with PEG placement for all patients [40]. Similar to prior to a

Table 3. Summary of published cases of peritonitis in PD patients after gynecologic procedures

PMID	Published year	Age	Procedure	Pro-phylaxis	Culture	Treatment	Prognosis
8465827	1993	42	Hysteroscopy	None	Group B <i>Streptococcus</i> , <i>Candida albicans</i>	Vancomycin, amphotericin B + flucytosine, PD catheter removal	Deceased
9284475	1997	41	Hysteroscopy with uterine polypectomy	None	<i>Candida glabrata</i>	Fluconazole + isoconazole, PD catheter removal	Survived
19293366	2009	41	Hysteroscopy with endometrial ablation	None	Group B <i>Streptococcus</i> , methicillin-sensitive <i>S. aureus</i> , <i>E. coli</i>	Ceftazidime + amikacin + vancomycin, PD catheter removal	Septic shock but survived
21084055 ^a	2010	49	Gynecologic physical exam	None	<i>Enterococcus</i> spp.	Imipenem/cilastatin + amikacin	Survived
			Gynecologic physical exam	None	No growth	Imipenem/cilastatin + amikacin	Survived
			Gynecologic physical exam	None	Gram-positive cocci	Imipenem/cilastatin + amikacin	Survived
22302931 ^a	2012	41	Cervical conization, endocervical curettage under colposcopy	None	<i>Stenotrophomonas maltophilia</i>	Cefazolin + gentamicin	Survived
			Pap smear	None	<i>Streptococcus viridans</i>	Cefazolin + gentamicin	Survived
			Pap smear	None	No growth	Vancomycin, PD catheter removal	Survived
24133084	2013	29	Laparoscopy with removal of a migrating IUD	None	<i>Comamonas testosteroni</i>	Ciprofloxacin	Survived
23936514 ^b /31028109	2013/2019	27	Hysteroscopy	None	No growth	Cefazolin + gentamicin	Survived
23936514 ^b /31028109	2013/2019	58	Hysteroscopy with endometrial curettage	None	No growth	Cefazolin + gentamicin	Survived
23936514 ^b /31028109	2013/2019	38	IUD insertion	None	Group B <i>Streptococcus</i>	Vancomycin + ceftazidime	Survived
23936514 ^b /31028109	2013/2019	45	IUD insertion	None	<i>Enterococcus faecalis</i>	Ceftriaxone + vancomycin	Survived
23936514 ^b /31028109	2013/2019	45	IUD removal	None	Group D <i>Streptococcus</i> , <i>E. coli</i>	Cefazolin + gentamicin, ceftriaxone	Survived
31028109	2019	37	Hysteroscopy with polypectomy	None	No growth	Cefazolin + ceftazidime	Survived
31028109	2019	44	Hysteroscopy	None	Group B <i>Streptococcus</i>	Cefazolin + gentamicin	Survived

Listed treatments were the final antibiotics selected after the result of culture data. References are listed in the online suppl. material. PD, peritoneal dialysis; nr, not reported; IUD, intrauterine device. ^a Both studies presented a single patient with multiple episodes of peritonitis. ^b Two studies presented the same patients. Each publication provided different data for this table.

colonoscopy, patients planning to undergo any upper endoscopy would benefit from keeping the abdomen dry prior to the procedure [25].

Gynecologic Procedures

Due to the proximity of the pelvis to the abdominal cavity, gynecologic procedures are suspected to increase the risk for peritonitis in PD patients [4, 25]. A diverse variety of gynecologic procedures have been reported to cause peritonitis, including pap smears, diagnostic hysteroscopies, endometrial polypectomies, endometrial curettages, cervical conizations, and both intrauterine device (IUD) implantations and removals [38, 50, 51]. The

most commonly reported organisms in the literature include Gram-negative bacilli, *Enterococcus* and *Streptococcus*, which are similar to the ones that are found most frequently in genitourinary tract infections (shown in Table 3; online suppl. Table 3). Due to the high prevalence of *Candida* in the mucosal surfaces of the external genitalia, it is not surprising that there has also been multiple reports of *Candida* peritonitis in PD patients who underwent gynecologic procedures [52–54]. Periprocedural fungal prophylaxis is not currently a guideline recommendation, but it could be considered in those known to have candidiasis.

Due to the concern for peritonitis, the ISPD 2016 guidelines recommend antibiotic prophylaxis in all patients undergoing invasive gynecologic procedures. They

suggest the same antibiotic regimen as that for colonoscopies: a single dose of IV ampicillin plus an aminoglycoside, with or without metronidazole [4]. The American College of Obstetricians and Gynecologists (ACOG) does not have a specific guideline for PD patients but recommends, in the general population, cefazolin prior to any hysterectomy or laparotomy and doxycycline prior to any uterine evacuations, like dilation and curettage [55].

The available data for prophylaxis in the setting of gynecologic procedures are weaker than the data for colonoscopies in PD patients [4, 50]. Two small retrospective studies did find that patients who received prophylactic antibiotics were able to avoid postprocedure peritonitis, though only one of the studies reached statistical significance when comparing peritonitis rates with patients who did not receive antibiotic prophylaxis prior to a gynecologic procedure [38, 50]. The prophylactic antibiotic regimen of choice was heterogeneous across both studies. Wu et al. [38] reported the use of oral clindamycin for 2 dilatation and curettages, as well as 1 hysteroscopy, and oral cefadroxil for a third reported dilatation and curettage. In contrast, Fan et al. [50] reported the use of 7 different prophylactic antibiotic regimens, with the most utilized one being oral cefadroxil 500 mg once daily for 3 days. Although there are no data, antibiotic prophylaxis is strongly suggested prior to childbirth, with most deliveries described in the literature requiring a caesarean section [56]. Similar to the 2 other abdominopelvic procedures discussed above, gynecologic procedures also require an empty peritoneal cavity to minimize the risk of peritonitis [56].

Conclusion

PD patients are at high risk for developing peritonitis after commonly routine procedures. The role of antibiotics in PD catheter insertion has been studied prospectively, but only small retrospective studies have looked at the benefits of antibiotic prophylaxis in other routine procedures. Additionally, the antibiotics chosen are quite heterogeneous within and across the different studies. Given the limits of the evidence in the PD population, there may be benefit in evaluating antibiotic prophylaxis recommendations from other societies and attempt to apply them to the setting of PD patients. For example, prior to dental procedures, the ISPD has adopted strategies for PD patients to prevent peritonitis with amoxicillin similar to that used by the American Heart Association to prevent

endocarditis in high-risk patients. ISPD currently suggests ampicillin plus an aminoglycoside, with or without metronidazole, prior to colonoscopies or gynecologic procedures. Potential alternatives to consider could be derived from the Surgical Infection Society (SIS) and IDSA guidelines for colorectal surgery due to the common bacteriology between postcolorectal surgical infections and PD-related peritonitis. Most cases in the literature report culprit organisms that would have been susceptible to either antibiotic regimen (shown in Tables 1–3; online suppl. Tables 1–3). Antibiotic prophylaxis prior to upper endoscopy is not currently recommended, but prophylaxis prior to PEG placement due to the violation of the peritoneum would likely be beneficial. Nonetheless, moving forward, large prospective trials will be useful for discerning the true benefits of periprocedural antibiotics, as well as the optimal regimen.

Statement of Ethics

The authors have no ethical conflicts of interest to disclose.

Conflict of Interest Statement

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Author Contributions

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Disclaimer

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