PD effluent specimen collection: Your questions answered

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Abstract

When a patient on Peritoneal Dialysis (PD) presents with suspected PD-related peritonitis (e.g. cloudy PD fluid and abdominal pain), one of the most important initial aspects of management is for the nephrology nurse/home dialysis nurse to collect PD effluent specimens for white white blood cells (WBC) count, Gram stain, culture and sensitivity for inspection and to send for laboratory testing before antibiotics are started. A review by seven members of the International Society for Peritoneal Dialysis (ISPD) Nursing Committee of all 133 questions posted to the ISPD website "Questions about PD" over the last four years (January 2018 – December 2021), revealed 97 posted by nephrology nurses from around the world. Of these 97 questions, 10 were noted to be related to best practices for PD effluent specimen collection.

For our review we focussed on these 10 questions along with their responses by the members of the ISPD "Ask The Experts Team", whereby existing best practice recommendations were considered, if available, relevant literature was cited and differences in international practice discussed. We revised the original responses for clarity and updated the references. We found that these 10 questions were quite varied but could be organized into four categories: how to collect PD effluent safely; how to proceed with PD effluent collection; how to collect PD effluent for assessment; and, how to proceed with follow-up PD effluent collection after IP antibiotics have been started.

In general, we found that there was limited evidence in the PD literature to answer several of these 10 questions posted to the ISPD website "Questions about PD" by nephrology nurses from around the world on this important clinical topic of best practices for PD effluent specimen collection. Some of these questions were also not addressed in the latest ISPD Peritonitis Guidelines. Moreover, when polling members of our ISPD Nursing Committee we found when answering a few of these questions, nursing practice varied within and among countries. We encourage PD nurses to conduct their own research on this important topic, focusing on areas where research evidence is lacking.

Take Home Points

- When the nurse is collecting a specimen of PD effluent to diagnose peritonitis, the nurse should use Standard Precautions, and, if available, a needleless device for his/her safety.
- When the PD effluent specimen collection is for the diagnosis of peritonitis, then the PD fluid should have dwelled in the patient's peritoneum for a minimum of two hours;
- There is no evidence to support the routine change of the transfer set during the course of peritonitis unless an obvious contamination event has occurred;
- When the course of antibiotics for peritonitis is completed, the PD effluent is clear and the patient is free of symptoms, there is no evidence to support the practice of routine collection of PD effluent for follow up cultures.

Introduction

One of the most important fundamental aspects of initial management of a patient on PD with suspected peritonitis is the careful collection of PD effluent for white blood cell (WBC) count, Gram stain, culture and sensitivity to send for laboratory testing before antibiotics are started(1). If a PD effluent sample for culture and sensitivities is not collected with meticulous care, then the sample can be contaminated, making the determination of appropriate antibiotic therapy challenging. Similarly, if the PD effluent sample for WBC count is not collected correctly, then the interpretation of the WBC count can be problematic.

Nephrology health care professionals from around the world can post questions about PD clinical practice to the ISPD website section "Questions about PD" www.ispd.org/questions/ . These questions are sent out by the Chair of the ISPD Education Committee for their responses to the ISPD "AskTheExpertsTeam". This ISPD "AskTheExpertsTeam" is made up of a group of Nephrologists and Nephrology Nurses from around the world, all members of ISPD. The Nephrology Nurses on this team of experts are also members of the ISPD Nursing Committee, whose goals include providing advice and resources to ISPD membership with respect to nursing issues related to PD.

Seven members of the ISPD Nursing Committee conducted a review from the last four years (January 2018 – December 2021) of all the 133 questions posted to the "Questions about PD" section of the ISPD website and found 97 were posted by nephrology nurses from around the world. Of these 97 questions, 10 were found to be questions related to different aspects of best practices for PD effluent specimen collection. The focus of this review is to highlight these 10 questions and their responses (7 were responded to by members of the ISPD Nursing Committee, 3 by Nephrologists). We detail these 10 questions and the responses below, with the original responses revised for clarity and the references updated.

How to collect PD effluent safely

Q: Working on the peritoneal effluent specimen collection. Any suggestion on how to collect it safely?

A: There are three main points we would like to make here regarding safety for PD nurses when collecting samples of PD effluent. First of all, Standard Precautions (which includes hand hygiene and personal protective equipment) are used today for all patient care in order to protect healthcare providers from infection and to prevent the spread of infection from patient to patient(2, 3). Second, added to this, is the concern that all occupational exposure to blood or other potentially infectious materials (OPIM) places healthcare workers at risk for infection. The U.S. Occupational Safety and Health Administration (OSHA) includes peritoneal fluid as one of the several types of human body fluids considered potentially infectious (4). Third, over the past two decades, there has been a major movement to decrease the number of needlestick injuries in health care workers. To this end, many needleless and safer needle devices have been introduced and the field continues to rapidly evolve(5).

A small convenience sample survey of members of the ISPD Nursing Committee (July 2020) from several different countries found that while it is still common practice in some countries to use a needle and syringe to transfer the PD effluent from the PD bag to blood culture bottles or sterile container, certainly in Australia, Canada, the United Kingdom and the United States there is definitely a movement to using needleless devices and safer needle devices to transfer PD effluent. We would recommend that you check with your local hospital and your dialysis provider to seek access to needleless devices and/or safer needle devices, including blunt needles and vacutainer connector transfer devices, you could use in your PD unit to minimize the risk for needle-stick injury for PD nurses while collecting samples of PD effluent (5).

How to proceed with PD effluent collection

Q: When obtaining a fluid sample for culture, what process should be followed on disinfecting prior to collection of fluid? Do you recommend cleaning the tops of culture bottles with an alcohol wipe prior to use (like collecting blood cultures)? Do you recommend cleaning the sample port with only Betadine or Alcavis, or will the alcohol wipe work as well? Is "clean catch" appropriate when collecting a sample?

A: In the latest ISPD Peritonitis Guidelines 2022, the recommendation for suspected peritonitis is that the collection of PD effluent in blood-culture bottles is the preferred technique for bacterial culture (1). However, the authors of these 2022 Guidelines do not comment on how to clean the rubber septa of the blood culture bottles to prevent contamination. The rubber septa of blood culture bottles are not sterile. The Centers for Disease Control and Prevention (CDC) recommends that blood culture bottle tops should be disinfected with isopropyl alcohol 70% and allowed to dry, and the American Society for Microbiology state that 70% isopropyl is the most common method used (6, 7) . Iodine products should not be used to disinfect blood culture bottle tops, as the iodine may result in erosion of the rubber and introduction of contaminants (6). We would also recommend each PD center checks with the requirements of their laboratories processing their PD effluent sent for cultures.

Regarding cleaning the sample/medication port of the PD effluent bag, there is some variation in practice. From an informal poll of nurses from different countries who are members of the ISPD Nursing Committee (February 2020), cleaning the sample port with a single-use, sterile alcohol pad/wipe (isopropyl alcohol 70%) is a common practice, one country uses Betadine (povidone-iodine 10%) single-use pads, another chlorhexidine 2% single-use pads – allow 30 seconds to dry and use aseptic non-touch technique.

One laboratory study conducted in Brazil compared different disinfection techniques for the PD bag sample/medication port by testing two different cleaning agents (70% alcohol vs 2% chlorhexidine) and time periods (5, 10 and 60 seconds) for disinfection of the medication port. Five microorganisms (*S. aureus, E. coli, A. baumannii C. parapsilosis*, and *Coagulase negative staphylococcus*) were prepared for use as contaminants of the medication port. The results of the study suggested that in cases where the medication port is used for medication administration or sample collection, the cleaning procedure should be performed through friction using 2% chlorhexidine for at least 5 seconds; if 70% alcohol is used the length of friction should not be inferior to 10 seconds(8) . However, in this study, neither Betadine nor Alcavis 50 were tested; Betadine is no longer used in disinfection of intravenous medication ports in Brazil and Alcavis 50 is not available. Alcavis 50 (electrolytically produced sodium hypochlorite) has been used for different purposes in dialysis with effective results preventing infections (9-11) , but no study was found in relation to using Alcavis 50 to disinfect the medication port.

Other general recommendations to minimize contamination when taking PD effluent samples include the use of personal protection equipment, hand hygiene, don clean gloves before collecting the samples and, for maximal effect, allow the antiseptic used on the sample port to dry. From an informal poll of international members of the Nursing Committee of the ISPD (February 2020), we found methods for collecting the PD effluent sample for presumed peritonitis varied within countries and between countries; however, we would **not** recommend a “clean catch” (pouring from drain bag into a sterile urine cup).

Q: When a patient has a suspected peritonitis, when should the transfer set/extension set to be changed? Before or after sampling PD effluent and what is the rationale?

A: Two small, single-centre studies, both conducted multiple years ago, showed that changing the transfer set did not reduce the incidence of relapsing peritonitis compared to not changing the transfer set (12, 13) .

From an informal poll of international members of the ISPD Nursing Committee (December 2019), practices do vary considerably among different countries. In general, in the United States, it is common practice to change the transfer set of a patient on PD with suspected peritonitis – the set is changed after the collection of the PD effluent sample, but before the administration of antibiotics. The rationale being to prevent any micro-organisms residing in the transfer set (e.g. in a biofilm) from re-infecting the patient. We are not aware of any research evidence for this practice. In Brazil, the transfer set is changed only after an episode of relapsing peritonitis – an episode that happens within 4 weeks of completion of therapy of a prior episode with the same organism or one sterile (culture negative) episode as defined by the ISPD definition. The rationale here again is that it could be microorganisms in the intraluminal biofilm in the transfer set causing the relapsing peritonitis (14, 15). On the other hand, a study looking at biofilm in transfer sets changed routinely every 6 months stated that microorganisms were not recovered from the transfer set in the majority of situations when an infection episode occurred before transfer set removal(16).

In Japan and Canada, the practice varies from one PD center to another, some centers changing the transfer set routinely for a patient with suspected peritonitis, while other centers do not. In general, in the Australia, New Zealand and the United Kingdom, it is not a standard practice to change the transfer set for a patient with suspected peritonitis, unless an obvious contaminating event has occurred. Clearly, this topic is an area that would benefit from further research.

How to collect PD effluent for assessment

Q: Is there a guideline on how patients on Automated Peritoneal Dialysis (APD) should check cloudiness of the effluent if they use drain line instead of drain bags?

Q: Does the ISPD have a position on use of Effluent Sample Bags specifically developed and designed to collect specimens from the patient transfer set for culture when peritonitis is suspected? The sample bag that I have seen is made by a well- known vendor of CAPD solutions and supplies (dual bag, y-connection), and the procedure for collection of the specimen mirrors that used for connection and disconnection during an exchange. The product is essentially a miniature drain bag. There is no instillation of solution involved.

A: From a small convenience sample survey of members of the ISPD Nursing Committee (August 2021), one nurse from the United States and one from Brazil both recommended to teach the patient on APD using a drain line, to drain the effluent from the drain line into a clear glass jar (or any clean and transparent container) with sufficient volume to enable the patient to visually

check the clarity of the fluid. Authors have long acknowledged the potential problem of delayed detection of peritonitis for patients on APD (17, 18).

ISPD does not have a position statement on the practice of using effluent sample bags to collect a specimen of PD effluent from a patient with suspected peritonitis. We understand some PD units in the United States do use these effluent sample bags to collect the PD fluid, reasoning that, while there is an added cost, the benefit is that these small bags do have an injection port. Thus, a nurse, using aseptic technique, can use the injection port of the small collection bag to aspirate a sample of the PD effluent and then transfer this aspirated PD effluent to a sterile collection container, for example, blood culture bottles. The risk of contamination of the PD effluent at this time is therefore minimized. It should be noted that not all single drainage bags for PD fluid have an injection port.

The development of point-of-care devices to detect changes in PD effluent for infection whilst a patient is on PD is an area of interest and early developments have begun in this area(19, 20).

Q: Could we use the last fill of PD cycler treatment from last night to obtain a PD fluid sample? Or do we need to instill a new 1.5% PD solution for two hours and then get our PD sample for cell count and culture?

A: If the patient is on APD with a last fill and is suspected to have peritonitis, then the patient should be instructed to drain the PD effluent from the "last fill" into a separate manual drain bag and inspect for cloudiness. If in doubt, a sample of PD effluent should be sent for Gram stain, culture and sensitivity, and WBC count. We also recommend that if the patient had only 30 minutes of the last fill, then the patient would need to wait at least 1.5 hours before draining (1). Only if the patient has "dry days" does the nurse need to first instil 1 L of 1.5% PD fluid and wait at least two hours before draining. Then inspect the PD effluent for cloudiness, and send the fluid for Gram stain, culture and sensitivity, and WBC count (1).

Diagnosing peritonitis can be difficult in patients on APD therapy, frequent dialysate exchanges can minimize symptoms and deplete macrophages, thereby reducing defences. In addition frequent exchanges can lead to the presence of clearer effluent, making it more difficult to detect turbidness (17). The concern with short dwells is that the WBC count in the PD effluent may not cross the 100 per microliter (µL) threshold. In cases like this, the cell count differential, percentage of polymorphonucleates (PMN), rather than the absolute WBC count is necessary to diagnose peritonitis, and a proportion above 50% PMN is strong evidence of peritonitis, even if the absolute WBC count is less than 100/µL (21). In a patient presenting with abdominal pain and a dry abdomen the recommendation is to infuse one liter of dialysis solution and let it dwell for a minimum of two hours, otherwise an absolute WBC count may not exceed the 100/ microliter but the differential of > 50% PMNs would support the diagnosis of peritonitis (1).

How to proceed with the follow-up PD effluent collection after IP antibiotics have been started

Q: When a patient is on antibiotics for peritonitis, when is the proper timing to get samples for cultures. How much of a difference is there with obtaining a sample after 1 hour of dwell vs 6+ hours of dwell.

A: Routine cultures do not need to be collected for a PD patient on antibiotics for peritonitis if the patient's symptoms and PD effluent WBC count are improving. If the patient on PD with peritonitis is not improving after 48 hours on antibiotics, and then, according to the most recent 2022 ISPD Peritonitis Guideline Recommendations(1), the PD effluent for WBC count and cultures should be repeated. Similarly, if the patient's initial PD effluent culture is culture negative and symptoms/WBC count from PD effluent are not improving after 72 hours, then cultures (to exclude unusual organisms such as fungus) and WBC count should be repeated. For both of these instances, the PD fluid should have dwelled in the patient's peritoneum for a minimum of 2 hours, before being drained and sent for culture and sensitivities and WBC count laboratory testing.

Results from certain studies have indicated that PD effluent samples for culture and WBC count collected after a short dwell (e.g. 1 hour) are associated with more culture-negative samples and low WBC counts compared to those collected after a longer dwell time (e.g. at least 2 hours, as recommended in the ISPD Peritonitis guidelines) (1, 22, 23). Treatment and management of a patient with culture-negative peritonitis (no causative organism identified) is problematic and may result in the use of unnecessary or inappropriate antibiotics. Above all, standardization of collection of PD effluent samples for culture and WBC count (following ISPD Peritonitis Guidelines), should result in the causative organism with sensitivities being identified more often (culture-positive peritonitis), as well as facilitating interpretation of WBC counts, thus improving management of a patient on PD with peritonitis (1, 24-27).

Q: I have always performed follow up PDF Cultures 7-14 days post antibiotic treatment for peritonitis. I have been informed not all dialysis units practice this. I have searched the ISPD Guidelines on detailed recommendations but unsuccessful. Is this not necessary?

A: If the patient's response to the treatment is good, peritonitis is resolved (peritoneal fluid clear and no symptoms) and antibiotic treatment is completed according to ISPD Guidelines, (1) there are no recommendations to repeat further PD fluid cultures.

Q: Does the routine collection of PD fluid cultures 2 weeks after the completion of antibiotics for PD peritonitis detect relapsing or recurrent peritonitis more effectively than waiting for clinical signs/symptoms of peritonitis to develop in the absence of repeat cultures? What are the recommendations around this practice?

A: There is no evidence that conducting routine dialysate cultures is of benefit after successful treatment of a peritonitis episode. Typically, if there are still organisms in the dialysate, the patient will have ongoing signs and symptoms of peritonitis (cloudy fluid, abdominal pain, etc.).

If they are free of symptoms and the fluid is clear, the yield of routine fluid cultures would be extremely low.

Q: A patient treated for Staphylococcus epidermidis peritonitis with IP antibiotics per ISPD guidelines. Post antibiotics his cultures still show Staphylococcus epidermidis but cell count and differential is negative. How can the cell count be normal but still Staphylococcus epidermidis?

A: If the patient has no pain and the effluent is clear with a normal cell count, the *Staphylococcus epidermidis* on the follow up culture may simply be a contaminant. It would be best to repeat the cell count and culture to confirm that this is the case.

In summary, in this article, members of the ISPD Nursing Committee have reviewed and updated responses to questions related to best practices for PD effluent specimen collection posted by nephrology nurses from around the world over the last four years on the ISPD website "Questions about PD". Based on our research into these questions, we have identified that there is limited evidence in the PD literature to answer several of the questions on this important clinical topic, and, to answer a some of the questions, there are no specific recommendations in the latest ISPD Peritonitis Guidelines. Moreover, when trying to answer a few of these questions, experiences of members from different countries of our ISPD Nursing Committee have shown variations in PD nursing practice within and among countries. To answer certain questions, however, we found that there are best practice recommendations published by well recognized specialty health care organizations that are quite relevant and should be used to guide our practice. We encourage PD nurses to conduct their own research projects on this most important topic of PD effluent specimen collection, focusing on areas where research evidence is lacking.

References

1. Li PK CK, Cho Y, Fan S, Figueiredo AE, Harris T, Kanjanabuch T, Kim YL, Madero M, Malyszko J, Mehrotra R, Okpechi IG, Perl J, Piraino B, Runnegar N, Teitelbaum I, Wong JK, Yu X, Johnson DW. ISPD peritonitis guideline recommendations: 2022 update on prevention and treatment. Perit Dial Int. 2022;42(2):110-53.
2. CDC. Center for Disease Control and Precvention. Standard Precautions for All Patient Care (updated January 2016 2016 [Available from: https://www.cdc.gov/infectioncontrol/basics/standard-precautions.html.
3. Curran ET. Standard precautions: what is meant and what is not. Journal of Hospital Infection. 2015;90(1):10-1.
4. USDL. United States Department of Labor: Occupational Safety and Health Administration - Bloodborne Pathogens and Needlestick Prevention [Available from: https://www.osha.gov/bloodborne-pathogens/hazards.

5. WHO. World Health Organization. Guideline on the use of safety-engineered syringes for intramuscular, intradermal and subcutaneous injections in health care settings: World Health Organization; 2016 [Accessed April 6 2022.]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK390474/.
6. Doern GV, Carroll KC, Diekema DJ, Garey KW, Rupp ME, Weinstein MP, et al. Practical guidance for clinical microbiology laboratories: a comprehensive update on the problem of blood culture contamination and a discussion of methods for addressing the problem. Clinical microbiology reviews. 2019;33(1):e00009-19.
7. CDC. Center of Disease Contyrol and Prevention. Clinician Guide for Collecting Cultures. Updated April 2015 2015 [Available from: Available at: http://medbox.iiab.me/modules/en-cdc/www.cdc.gov/getsmart/healthcare/implementation/clinicianguide.html.
8. Conti A, Katzap RM, Poli-de-Figueiredo CE, Pagnussatti V, Figueiredo AE. Disinfection of the Peritoneal Dialysis Bag Medication Port: Comparison of Disinfectant Agent and Disinfection Time. Nephrology (Carlton). 2017.
9. Mishkin GJ. Compatibility of electrolytically produced sodium hypochlorite solutions on long-term implanted dialysis catheters. Contrib Nephrol. 2007;154:72-83.
10. Cruz DN, Ocampo C, Brendolan A, Menara G, Corradi V, de Cal M, et al. Effectiveness of sodium hypochlorite in the prevention of catheter related infections. Contrib Nephrol. 2007;154:97-102.
11. Clere JN, L.; Motter, .S; Cassin, M.; Moran, J. Alcavis protocol improves peritonitis rates by reducing touch contamination. Perit Dial Int. 2014;34(suppl 1):S14.
12. Wong FS-Y, Chau S-K, Chow N-Y, Ho JC-F, Cheng Y-L, Yu AW-Y. Effect of Changing Transfer Set on Relapse of Bacterial Peritonitis. Hong Kong Journal of Nephrology. 2004;6(2):87-91.
13. Richmond D, Giminez LF, Reft C. Follow-up study to assess line changes with peritonitis. Adv Perit Dial. 1990;6:148-9.
14. Martins M, Rodrigues A, Pedrosa JM, Carvalho MJ, Cabrita A, Oliveira R. Update on the challenging role of biofilms in peritoneal dialysis. Biofouling. 2013;29(8):1015-27.
15. Sampaio J, Machado D, Gomes AM, Machado I, Santos C, Lima N, et al. Deciphering the Contribution of Biofilm to the Pathogenesis of Peritoneal Dialysis Infections: Characterization and Microbial Behaviour on Dialysis Fluids. PLOS ONE. 2016;11(6):e0157870.
16. Rodrigues A, Maciel M, Santos C, Machado D, Sampaio J, Lima N, et al. Peritoneal dialysis infections: An opportunity for improvement. American journal of infection control. 2014;42(9):1016-8.
17. Diaz-Buxo JA, Crawford TL, editors. Peritonitis in continuous cycling peritoneal dialysis. Advances in Peritoneal dialysis Conference on Peritoneal Dialysis; 2002.
18. Steele M, Kwan J. Potential problem: delayed detection of peritonitis by patients receiving home automated peritoneal dialysis (APD). Peritoneal Dialysis International. 1997;17(6):617-.
19. Goodlad C, George S, Sandoval S, Mepham S, Parekh G, Eberl M, et al. Measurement of innate immune response biomarkers in peritoneal dialysis effluent using a rapid diagnostic point-of-care device as a diagnostic indicator of peritonitis. Kidney International. 2020;97(6):1253-9.
20. Fung WW-S, Li PK-T. Recent advances in novel diagnostic testing for peritoneal dialysis-related peritonitis. Kidney Research and Clinical Practice. 2022;41(2):156-64.
21. Flanigan MJ, Freeman RM, Lim VS. Cellular response to peritonitis among peritoneal dialysis patients. Am J Kidney Dis. 1985;6(6):420-4.
22. Davis TK, Bryant KA, Rodean J, Richardson T, Selvarangan R, Qin X, et al. Variability in Culture-Negative Peritonitis Rates in Pediatric Peritoneal Dialysis Programs in the United States. Clinical Journal of the American Society of Nephrology. 2021;16(2):233-40.
23. Najafi I, Ossareh S, Hosseini M, Ganji Mr, Naghibi M, Makhdoomi K, Et Al. Epidemiology of Culture-Negative Peritonitis in Iranian patients on Continuous Ambulatory Peritoneal Dialysis. Iranian Journal Of Kidney Diseases (IJKD). 2011;5(5):332-7.

24. Kanjanabuch T, Chatsuwan T, Udomsantisuk N, Nopsopon T, Puapatanakul P, Halue G, et al. Association of Local Unit Sampling and Microbiology Laboratory Culture Practices With the Ability to Identify Causative Pathogens in Peritoneal Dialysis-Associated Peritonitis in Thailand. Kidney International Reports. 2021;6(4):1118-29.
25. Odudu A, Turner J, Coomer K, Salmon L, Yazdani F, Leung J. United Kingdom Survey of Culture-Negative Peritonitis and Dialysate Sampling Practice. Perit Dial Int. 2016;36(1):101-4.
26. Pangonis SF, Schaffzin JK, Claes D, Mortenson JE, Nehus E. An initiative to improve effluent culture detection among pediatric patients undergoing peritoneal dialysis through process improvement. Pediatric Nephrology. 2022.Published April 2022
27. Szeto CC, Wong TY, Chow KM, Leung CB, Li PK. The clinical course of culture-negative peritonitis complicating peritoneal dialysis. Am J Kidney Dis. 2003;42(3):567-74.