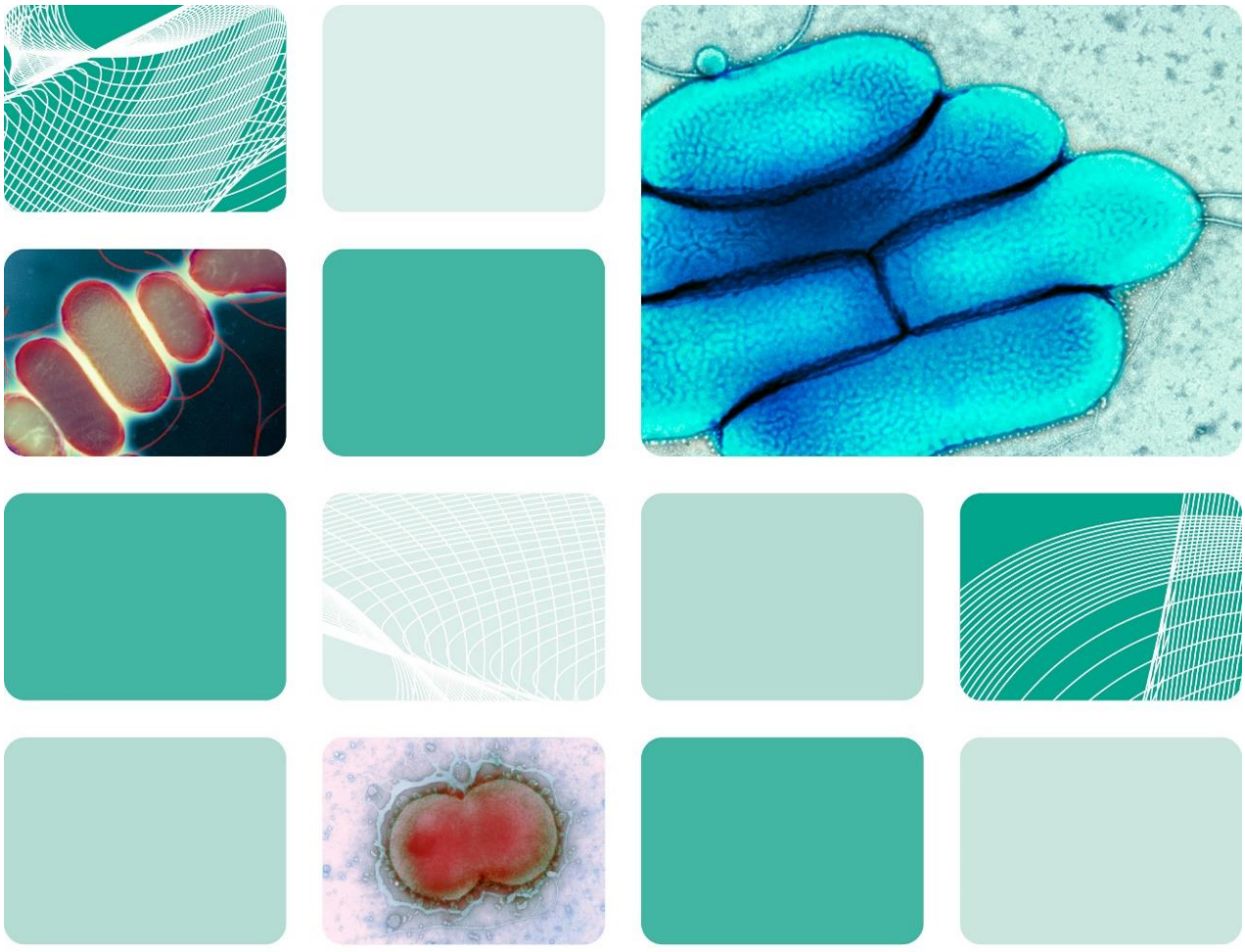
UK Health Security Agency

UK Standards for Microbiology Investigations

Investigation of continuous ambulatory peritoneal dialysis fluid



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Acknowledgments

UK Standards for Microbiology Investigations (UK SMIs) are developed under the auspices of UKHSA working in partnership with the partner organisations whose logos are displayed below and listed on the UK SMI website. UK SMIs are developed, reviewed and revised by various working groups which are overseen by a steering committee.

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UK SMIs are produced in association with:

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Contents

Amendment table

Each UK SMI document has an individual record of amendments. The amendments are listed on this page. The amendment history is available from standards@ukhsa.gov.uk.

Any alterations to this document should be controlled in accordance with the local document control process.

Amendment number/date	11/17.10.25
Issue number discarded	6
Insert issue number	6.1
Section(s) involved	**Amendment**
Whole document.	**This is an administrative point change.** **The content of this UK SMI document has not changed.** **The last scientific and clinical review was conducted on 20/02/2015.** Hyperlinks throughout document updated to Royal College of Pathologists website. Public Health England replaced with UK Health Security Agency throughout the document, including the updated Royal Coat of Arms Partner organisation logos updated. Broken links to devolved administrations replaced. References to NICE accreditation removed. Scope and Purpose replaced with General and Scientific information to align with current UK SMI template. 'Public health responsibilities of diagnostic Laboratories' section added.

Amendment No/Date.	10/**Error! Reference source not found.**
Issue no. discarded.	**Error! Reference source not found.**
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Section(s) involved	**Amendment**
Whole document.	Hyperlinks updated to gov.uk.

Page 2.	Updated logos added.
Whole document.	Scientific content reviewed and no substantive changes made.
Table and Appendix.	Antimicrobial substance testing removed.
References.	References reviewed and updated.

1 General information

View general information related to UK SMIs.

2 Scientific information

View scientific information related to UK SMIs.

3 Scope of document

Type of Specimen

Continuous ambulatory peritoneal dialysis (CAPD) fluid

Scope

This UK SMI describes the processing and microbiological investigation of continuous ambulatory peritoneal dialysis fluid.

This UK SMI should be used in conjunction with other UK SMIs.

4 Introduction

Continuous ambulatory peritoneal dialysis (CAPD) is used as an alternative to haemodialysis for the management of patients with end-stage renal failure. In this procedure the patient's own peritoneal membrane is used to dialyse waste products from the patient's blood. CAPD encompasses a closed system of commercially prepared sterile dialysate fluid in a bag, connected by silastic tubing to a Tenchkoff catheter which leads the fluid in and out of the peritoneal cavity. This achieves hyperosmolar ultrafiltration across the peritoneal membrane. Usually, 1-2 litres of dialysate is infused every 6 hours and the effluent drainage is collected by gravity into the empty dialysate bag at the end of each cycle.

CAPD has many advantages over haemodialysis. There is no requirement for vascular access or for specialised equipment in the home. Moreover, patients are more mobile and independent and are able to carry out the bag changes without assistance.

However, peritonitis is a frequent complication of CAPD[1]. Most CAPD infections arise from direct contamination of the catheter. On rare occasions infections may originate from an intra-abdominal focus such as diverticulitis[1]. The vast majority of CAPD infections are unimicrobial. Infection may involve the catheter exit site, subcutaneous tunnel, or the peritoneum.

Clinical manifestations of infection in patients undergoing CAPD include:

- Cloudy dialysis effluent
- Abdominal pain and tenderness
- Fever
- Nausea

- Vomiting
- Chills
- Erythema at the catheter site
- Discharge at the catheter site
- Catheter malfunction and drainage problems

4.1 Diagnosis of CAPD Peritonitis

This requires high quality microbiological facilities and close liaison between the clinician and microbiology department. Clinical diagnosis is usually based on the presence of at least two of the following criteria:

- Cloudy dialysate effluent
- Symptoms of peritonitis
- Positive culture and/or Gram stain of peritoneal fluid

Microscopy

Cloudiness generally represents a white blood cell (WBC) count of >100 x 10^6 per litre[1]. The presence of chyle, fibrin or blood may also cause turbidity, so microscopy is essential to confirm the presence of WBCs. Fluids with WBC counts of 50 - 100 x 10^6 per litre may be macroscopically clear.

The presence of >100 WBC x 10^6 per litre correlates closely with infection[1], although many false negative culture results have been reported. This is less likely with WBC counts of 500 x 10^6 per litre or above[1]. However, low WBC counts of <100 x10^6 per litre may be associated with the early stages of infection[1].

In most infected dialysates polymorphonuclear leucocytes (PMNs) predominate[1,2]. Routine differentiation of WBC morphology is of little diagnostic value[3]. However, >100 x10^6 eosinophils per litre can indicate allergic reaction, and occur in patients with the aetiologically unclear "eosinophilic peritonitis", with fungal peritonitis, or in those who have received intraperitoneal or systemic antibiotics[1].

There is no correlation between the WBC count and the number of bacteria present in dialysis effluent. Despite large numbers of WBCs, organisms may not be visible or they may be present in low numbers because of their sequestration within the phagocytes. Hence sensitivity of Gram stain is low (about 50%) except where there are large numbers of organisms present[1].

Culture

Recovery of organisms on culture may be difficult therefore the UK Renal Association recommends that the negative peritoneal fluid culture rates in patients with clinical peritonitis should be less than 10% although others have disputed this figure as too low. Recovery of organisms in culture can be increased by lysis of WBCs which releases sequestered organisms[4]. Various methods for lysing WBCs with varying degrees of success in recovering the organisms have been reported and these are covered in more detail below:

- Water lysis is recommended to minimise the problem of toxicity to delicate organisms that was encountered when lytic agents such as bile salts or Triton-X were used and reduces the risk of contamination found with broth methods[5]
- A lysis-centrifugation method will yield a positive culture rate of about 85%[2,6,7]. There is currently no satisfactory culture method for detecting the cause of the remaining 15% culture negative, clinically infected patients[3]
- Filtration of unlysed CAPD effluent and enrichment methods of culture are less sensitive than centrifugation after white cell lysis; both are more sensitive than centrifugation without white cell lysis[5]

Coagulase negative staphylococci are the commonest causes of CAPD peritonitis, but also the commonest laboratory contaminants[3].

Direct inoculation of blood culture bottles by CAPD staff is popular[8-11]. This method of culture may be useful for the early detection of infection where there will be a delay in receipt of the CAPD dialysate in the laboratory[12]. A protocol to minimise ward-based contamination during sampling and inoculation of blood culture bottles should be agreed with clinical staff, similar to that used for regular blood cultures. For patients on treatment, blood culture bottles containing antimicrobial removal resins are reported as having a higher isolation rate than those without[9,12]. The bottles should be accompanied by a separate specimen for microscopy and direct culture. Inclusion of direct culture on blood-containing media is recommended to allow recovery of fastidious micro-organisms that will not grow in blood culture bottles that do not contain blood.

Organisms most commonly isolated from CAPD dialysate are[1,10]:

- Coagulase negative staphylococci
- *Staphylococcus aureus*
- Enterobacteriaceae
- Pseudomonads
- *Acinetobacter* species
- Enterococci
- Streptococci
- *Corynebacterium* species

This list is not exhaustive, and a wide range of unusual and fastidious organisms have been isolated from CAPD dialysate[1].

Anaerobes are a relatively uncommon cause of CAPD peritonitis, but do occur as a result of bowel perforation (eg in diverticulitis).

Mycobacterium species - if routine cultures are negative and abnormal dialysate findings persist after treatment of presumed or documented bacterial peritonitis, evidence of infection with *M. tuberculosis* should be sought particularly if tuberculosis is endemic in the patients country of origin[13-15].

Non-tuberculous *Mycobacterium* species are identified, although rarely, as causes of infective peritonitis in patients undergoing CAPD.

Fungal peritonitis occurs with the most common isolates being *Candida* species[16,17]. *Cryptococcus neoformans* may be isolated, although rarely[18].

Polymicrobial infections have been reported and should be considered in certain patients[2].

16S rDNA PCR and other non-culture detection methods may be a useful diagnostic tool in addition to culture for certain cases[19].

5 Technical Information/Limitations

Limitations of UK SMIs

The recommendations made in UK SMIs are based on evidence (eg, sensitivity and specificity) where available, expert opinion and pragmatism, with consideration also being given to available resources. Laboratories should take account of local requirements and undertake additional investigations where appropriate. Prior to use, laboratories should ensure that all commercial and in-house tests have been validated and are fit for purpose.

Selective Media in Screening Procedures

Selective media which does not support the growth of all circulating strains of organisms may be recommended based on the evidence available. A balance therefore must be sought between available evidence, and available resources required if more than one media plate is used.

Specimen Containers[20,21]

UK SMIs use the term “CE marked leak proof container” to describe containers bearing the CE marking used for the collection and transport of clinical specimens. The requirements for specimen containers are given in the EU in vitro Diagnostic Medical Devices Directive (98/79/EC Annex 1 B 2.1) which states: “The design must allow easy handling and, where necessary, reduce as far as possible contamination of, and leakage from, the device during use and, in the case of specimen receptacles, the risk of contamination of the specimen. The manufacturing processes must be appropriate for these purposes”.

6 Safety Considerations[20-36]

6.1 Specimen Collection, Transport and Storage[20-25]

Use aseptic technique.

Collect specimens in appropriate CE marked leak proof containers and transport in sealed plastic bags.

Large volumes or whole dialysate bags may require special transportation according to local protocols. They should be transported in rigid, leakproof outer containers.

Compliance with postal, transport and storage regulations is essential.

6.2 Specimen Processing[20-36]

Containment Level 2.

Where Hazard Group 3 *Mycobacterium* species are suspected, all specimens must be processed in a microbiological safety cabinet under full containment level 3 conditions.

Laboratory procedures that give rise to infectious aerosols must be conducted in a microbiological safety cabinet[28].

Prior to staining, fix smeared material by placing the slide on an electric hotplate (65-75°C), under the hood, until dry. Then place in a rack or other suitable holder.

Note: Heat-fixing may not kill all *Mycobacterium* species[37]. Slides should be handled carefully.

Centrifugation must be carried out in sealed buckets which are subsequently opened in a microbiological safety cabinet.

Specimen containers must also be placed in a suitable holder.

Refer to current guidance on the safe handling of all organisms documented in this UK SMI.

The above guidance should be supplemented with local COSHH and risk assessments.

7 Specimen Collection

7.1 Type of Specimens

Continuous ambulatory peritoneal dialysis (CAPD) fluid

7.2 Optimal Time and Method of Collection[38]

For safety considerations refer to Section 6.1.

Collect specimens before antimicrobial therapy where possible[38].

Unless otherwise stated, swabs for bacterial and fungal culture should be placed in appropriate transport medium[39-43].

Collect specimens other than swabs into appropriate CE marked leak proof containers and place in sealed plastic bags.

Receipt of the whole dialysate bag is preferable so that sampling under controlled laboratory conditions may be performed.

Where safe transport and receipt of the whole bag is considered impractical, withdraw fluid aseptically from the injection port of the plastic dialysate bag with a sterile needle and syringe and transfer to a microbiologically approved container[21,44].

If blood culture bottles are used they should be inoculated aseptically with 5-10mL of dialysate according to local protocol agreed between the laboratory and clinical staff.

7.3 Adequate Quantity and Appropriate Number of Specimens[38]

A volume of 10-50mL of fluid is considered suitable. Blood culture bottles may also be inoculated and submitted to the laboratory in addition to the pure sample.

Numbers and frequency of specimen collection are dependent on clinical condition of patient.

8 Specimen Transport and Storage[20,21]

8.1 Optimal Transport and Storage Conditions

For safety considerations refer to Section 6.1.

Specimens should be transported and processed as soon as possible[38].

If processing is delayed, refrigeration is preferable to storage at ambient temperature[38].

9 Specimen Processing/Procedure[20,21]

9.1 Test Selection

Microscopy and culture for *Mycobacterium* species if routine bacteriology cultures are negative and abnormal dialysate findings persist - see UK SMI B 40 - Investigation of Specimens for Mycobacterium species.

9.2 Appearance

Describe as clear or cloudy fluid.

9.3 Sample Preparation

For safety considerations refer to Section 6.2.

Standard

Water-lysis method

Centrifuge 25mL of dialysate at 1500 x g for 5min.

Discard the supernatant or transfer to another microbiologically approved container for further testing if required leaving approximately 0.5mL deposit[21].

Resuspend the centrifuged deposit in 10mL of sterile distilled water by vigorous shaking for 30sec[45].

Centrifuge at 1500 x g for 5min.

Discard the supernatant, leaving approximately 0.5mL.

Resuspend the centrifuged deposit in the remaining fluid.

Blood Culture Bottles

If blood culture bottles are used they should be inoculated aseptically with 5-10mL of dialysate[10].

Supplementary

Mycobacterium species - UK SMI B 40 - Investigation of Specimens for Mycobacterium species.

9.4 Microscopy

9.4.1 Standard

Cell count

Perform total cell count on uncentrifuged specimen[3].

9.4.2 Supplementary

Gram stain

Place one drop of centrifuged deposit (see Section 4.5.1) with a sterile pipette on to a clean microscope slide[3].

Spread this with a sterile loop to make a thin smear for Gram staining.

Differential leucocyte counts for eosinophils (for total counts of >100 x 10^6 WBC/L)

Prepare a slide from the centrifuged deposit as for Gram stain but allow to air dry because heat fixation distorts the cellular morphology. Fix in alcohol and stain with a stain suitable for WBC differentiation.

Patients with low WBC counts have been shown to be culture negative[10].

Microscopy for Mycobacterium species - see UK SMI B 40 - Investigation of Specimens for Mycobacterium species.

9.5 Culture and Investigation

Inoculate each agar plate with centrifuged deposit using a sterile pipette (UK SMI Q 5 - Inoculation of Culture Media for Bacteriology).

For the isolation of individual colonies, spread inoculum with a sterile loop.

9.5.1 Culture media, conditions and organisms

Clinical details/ conditions	Specimen	Standard media	Incubation			Cultures read	Target organism(s)
			Temp. °C	Atmos.	Time		
All conditions	CAPD	Blood agar	35-37	5-10% CO_2	40-48hr	daily	Any organism
		Blood agar	28-30	air	40-48hr	daily	Psychrophilic pseudomonads
		Fastidious anaerobe agar	35-37	anaerobic	40-48hr*	≥40hr	Anaerobes

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For these situations, add the following:							
Clinical details/ conditions	**Specimen**	**Supplementary media**	**Incubation**			**Cultures read**	**Target organism(s)**
			Temp. °C	**Atmos.**	**Time**		
Peritonitis (microscopy suggestive of mixed infection)	CAPD	Neomycin fastidious anaerobe agar with metronidazole 5µg disc	35-37	anaerobic	40-48hr*	≥40hr	Anaerobes
Clinical details/ conditions	**Specimen**	**Optional media**	**Incubation**			**Cultures read**	**Target organism(s)**
			Temp. °C	**Atmos.**	**Time**		
Peritonitis (microscopy suggestive of mixed infection)	CAPD	Staph/strep selective agar	35-37	air	40-48hr	daily	*S. aureus* Streptococci
		CLED/MacConkey agar	35-37	air	16-24hr	≥16hr	Enterobacteriaceae
		Sabouraud agar	35-37	air	40-48hr*	≥40hr	Fungi
If bottles received or for enrichment. Any suspected infection	CAPD	Enriched culture eg Blood culture bottles subcultured to: Blood agar Fastidious anaerobe agar	35-37 35-37 35-37	air 5-10% CO_2 anaerobic	40-48hr 40-48hr 40-48hr	continuous monitoring (minimum 40-48hr) Daily Terminal subculture if appropriate ≥40hr	Any organism
Other organisms for consideration – *Mycobacterium* species (B 40)							
*incubation may be extended to 5 d if clinically indicated; in such cases plates should be read at ≥40hr and then left in the incubator/cabinet until day 5. Certain opportunistic pathogens will require extended incubation.							

9.6 Identification

Refer to individual UK SMIs for organism identification.

9.6.1 Minimum level of identification in the laboratory

Anaerobes	“anaerobes" level
β-haemolytic streptococci	Lancefield group level
Enterococcus	genus level
Coagulase negative staphylococci	"coagulase negative" level
All other organisms	species level

Organisms may be further identified if this is clinically or epidemiologically indicated.

Note: Any organism considered to be a contaminant may not require identification to species level.

Mycobacterium species see UK SMI B 40 - Investigation of Specimens for Mycobacterium species.

9.7 Antimicrobial Susceptibility Testing

Refer to British Society for Antimicrobial Chemotherapy (BSAC) and/or EUCAST guidelines. Prudent use of antimicrobials according to local and national protocols is recommended.

9.8 Referral for Outbreak Investigations

N/A

9.9 Referral to Reference Laboratories

For information on the tests offered, turnaround times, transport procedure and the other requirements of the reference laboratory see user manuals and request forms

Contact appropriate reference laboratory for information on the tests available, turnaround times, transport procedure and any other requirements for sample submission:

England

Wales

Scotland

Northern Ireland

Note: In case of sending away to laboratories for processing, ensure that specimen is placed in appropriate package and transported accordingly.

10 Reporting Procedure

10.1 Microscopy

Cell count

Report numbers of WBCs x 10^6 per litre.

Gram stain (if performed)

Report on organisms detected.

Differential leucocyte count (if performed)

Report numbers of eosinophils x 10^6 per litre.

Microscopy for *Mycobacterium* species – see UK SMI B 40 - Investigation of Specimens for Mycobacterium species.

Microscopy reporting time

Urgent microscopy results to be telephoned or sent electronically.

Written report, 16–72hr.

10.2 Culture

Report the organisms isolated **or**

Report absence of growth.

Also, report results of supplementary investigations.

10.2.1 Culture reporting time

Clinically urgent culture results to be telephoned or sent electronically.

Written report, 16–72hr stating, if appropriate, that a further report will be issued.

Supplementary investigations: *Mycobacterium* species - see UK SMI B 40 - Investigation of Specimens for Mycobacterium species.

10.3 Antimicrobial Susceptibility Testing

Report susceptibilities as clinically indicated. Prudent use of antimicrobials according to local and national protocols is recommended.

11 Notification to UKHSA [46,47] or Equivalent in the Devolved Administrations[48-51]

The Health Protection (Notification) regulations 2010 require diagnostic laboratories to notify UK Health Security Agency (UKHSA) when they identify the causative agents that are listed in Schedule 2 of the Regulations. Notifications must be provided in writing, on paper or electronically, within seven days. Urgent cases should be notified orally and as soon as possible, recommended within 24 hours. These should be followed up by written notification within seven days.

For the purposes of the Notification Regulations, the recipient of laboratory notifications is the local UKHSA Health Protection Team. If a case has already been notified by a registered medical practitioner, the diagnostic laboratory is still required to notify the case if they identify any evidence of an infection caused by a notifiable causative agent.

Notification under the Health Protection (Notification) Regulations 2010 does not replace voluntary reporting to UKHSA. The vast majority of NHS laboratories voluntarily report a wide range of laboratory diagnoses of causative agents to UKHSA and many UKHSA Health protection Teams have agreements with local laboratories for urgent reporting of some infections. This should continue.

Note: The Health Protection Legislation Guidance (2010) includes reporting of Human Immunodeficiency Virus (HIV) & Sexually Transmitted Infections (STIs), Healthcare Associated Infections (HCAIs) and Creutzfeldt–Jakob disease (CJD) under ‘Notification Duties of Registered Medical Practitioners’: it is not noted under ‘Notification Duties of Diagnostic Laboratories’.

https://www.gov.uk/government/organisations/uk-health-security-agency

Other arrangements exist in Scotland[48,49], Wales[50] and Northern Ireland[51].

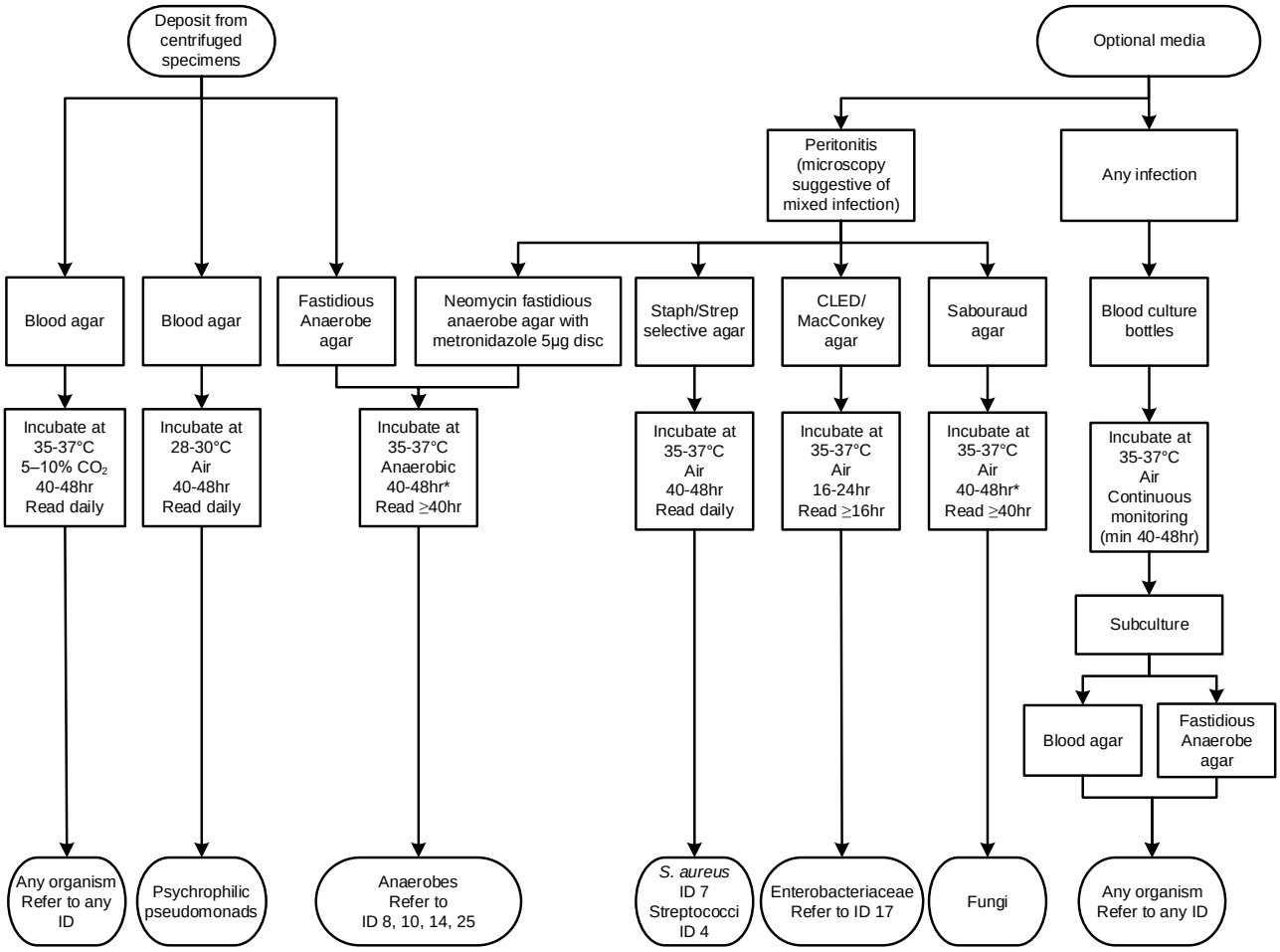
12 Public health responsibilities of diagnostic laboratories

Diagnostic laboratories have public health responsibility as part of their duties. Amongst these are additional local testing, or referral, to further characterise the organism, as required, primarily for public health purposes e.g. routine cryptosporidium detection; serotyping or microbial subtyping; and a duty to refer appropriate specimens and isolates of public health importance to a reference laboratory.

Diagnostic laboratory outputs inform public health intervention, and surveillance data is required to develop policy and guidance, forming an essential component of healthcare. It is recognised that additional testing and referral of samples may entail some costs that has to be borne by the laboratory but in certain jurisdictions these costs are covered centrally.

Diagnostic laboratories should be mindful of the impact of laboratory investigations on public health and consider requests from the reference laboratories for specimen referral or enhanced information.

Appendix: Investigation of continuous ambulatory peritoneal dialysis fluid



* Incubation may be extended to 5d if clinically indicated; in such cases plates should be read at ≥40hr and then left in the incubator / cabinet until day 5.

References

An explanation of the reference assessment used is available in the scientific information section on the UK SMI website.

1. von Graevenitz A, Amsterdam D. Microbiological aspects of peritonitis associated with continuous ambulatory peritoneal dialysis. Clin Microbiol Rev 1992;5:36-48.

2. Lin YC, Lin WP, Huang JY, Lee SY. Polymicrobial peritonitis following colonoscopic polypectomy in a peritoneal dialysis patient. Intern Med 2012;51:1841-3.

3. Ludlam HA. Infectious consequences of continuous ambulatory peritoneal dialysis. J Hosp Infect 1991;18 Suppl A:341-54.

4. Renal Association Standards Subcommittee, editor. Treatment of adults and children with renal failure: standards and audit measures. 3rd ed. London: Royal College of Physicians; 2002.

5. Ludlam H, Dickens A, Simpson A, Phillips I. A comparison of four culture methods for diagnosing infection in continuous ambulatory peritoneal dialysis. J Hosp Infect 1990;16:263-9.

6. Ludlam HA, Price TN, Berry AJ, Phillips I. Laboratory diagnosis of peritonitis in patients on continuous ambulatory peritoneal dialysis. J Clin Microbiol 1988;26:1757-62.

7. Gould IM, Casewell MW. The laboratory diagnosis of peritonitis during continuous ambulatory peritoneal dialysis. J Hosp Infect 1986;7:155-60.

8. Khare S, Yurack J, Toye B. Culture of dialysate in suspected CAPD associated peritonitis using the BacT/Alert system. Diagn Microbiol Infect Dis 1996;25:101-6.

9. Alfa MJ, Degagne P, Olson N, Harding GK. Improved detection of bacterial growth in continuous ambulatory peritoneal dialysis effluent by use of BacT/Alert FAN bottles. J Clin Microbiol 1997;35:862-6.

10. Iyer RN, Reddy AK, Gande S, Aiyangar A. Evaluation of different culture methods for the diagnosis of peritonitis in patients on continuous ambulatory peritoneal dialysis. Clin Microbiol Infect 2013.

11. Azap OK, Timurkaynak F, Sezer S, Cagir U, Yapar G, Arslan H, et al. Value of automatized blood culture systems in the diagnosis of continuous ambulatory peritoneal dialysis peritonitis. Transplant Proc 2006;38:411-2.

12. Howe PA, Fraise AP. Continuous ambulatory peritoneal dialysis: factors influencing recovery of organisms from effluents. Med Lab Sci 1991;48:114-7.

13. Lye WC. Rapid diagnosis of Mycobacterium tuberculous peritonitis in two continuous ambulatory peritoneal dialysis patients, using DNA amplification by polymerase chain reaction. Adv Perit Dial 2002;18:154-7.

14. Kwan JT, Hart PD, Raftery MJ, Cunningham J, Marsh FP. Mycobacterial infection is an important infective complication in British Asian dialysis patients. J Hosp Infect 1991;19:249-55.

15. Bendall RP, Drobniewski FA, Jayasena SD, Nye PM, Uttley AH, Scott GM. Restriction fragment length polymorphism analysis rules out cross- infection among renal patients with tuberculosis. J Hosp Infect 1995;30:51-6.

16. Quindos G, Cabrera F, Arilla MC, Burgos A, Ortiz-Vigon R, Canon JL, et al. Fatal Candida famata peritonitis in a patient undergoing continuous ambulatory peritoneal dialysis who was treated with fluconazole. Clin Infect Dis 1994;18:658-60.

17. Yuen KY, Seto WH, Ching TY, Cheung WC, Kwok Y, Chu YB. An outbreak of Candida tropicalis peritonitis in patients on intermittent peritoneal dialysis. J Hosp Infect 1992;22:65-72.

18. Yinnon AM, Solages A, Treanor JJ. Cryptococcal peritonitis: report of a case developing during continuous ambulatory peritoneal dialysis and review of the literature. Clin Infect Dis 1993;17:736-41.

19. Kim SH, Jeong HS, Kim YH, Song SA, Lee JY, Oh SH, et al. Evaluation of DNA extraction methods and their clinical application for direct detection of causative bacteria in continuous ambulatory peritoneal dialysis culture fluids from patients with peritonitis by using broad-range PCR. Ann Lab Med 2012;32:119-25.

20. European Parliament. UK Standards for Microbiology Investigations (SMIs) use the term "CE marked leak proof container" to describe containers bearing the CE marking used for the collection and transport of clinical specimens. The requirements for specimen containers are given in the EU in vitro Diagnostic Medical Devices Directive (98/79/EC Annex 1 B 2.1) which states: "The design must allow easy handling and, where necessary, reduce as far as possible contamination of, and leakage from, the device during use and, in the case of specimen receptacles, the risk of contamination of the specimen. The manufacturing processes must be appropriate for these purposes".

21. Official Journal of the European Communities. Directive 98/79/EC of the European Parliament and of the Council of 27 October 1998 on *in vitro* diagnostic medical devices. 7-12-1998. p. 1-37.

22. Health and Safety Executive. Safe use of pneumatic air tube transport systems for pathology specimens. 9/99.

23. Department for transport. Transport of Infectious Substances, 2011 Revision 5. 2011.

24. World Health Organization. Guidance on regulations for the Transport of Infectious Substances 2013-2014. 2012.

25. Home Office. Anti-terrorism, Crime and Security Act. 2001 (as amended).

26. Advisory Committee on Dangerous Pathogens. The Approved List of Biological Agents. Health and Safety Executive. 2013. p. 1-32

27. Advisory Committee on Dangerous Pathogens. Infections at work: Controlling the risks. Her Majesty's Stationery Office. 2003.

28. Advisory Committee on Dangerous Pathogens. Biological agents: Managing the risks in laboratories and healthcare premises. Health and Safety Executive. 2005.

29. Advisory Committee on Dangerous Pathogens. Biological Agents: Managing the Risks in Laboratories and Healthcare Premises. Appendix 1.2 Transport of Infectious Substances - Revision. Health and Safety Executive. 2008.

30. Centers for Disease Control and Prevention. Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories. MMWR Surveill Summ 2012;61:1-102.

31. Health and Safety Executive. Control of Substances Hazardous to Health Regulations. The Control of Substances Hazardous to Health Regulations 2002. 5th ed. HSE Books; 2002.

32. Health and Safety Executive. Five Steps to Risk Assessment: A Step by Step Guide to a Safer and Healthier Workplace. HSE Books. 2002.

33. Health and Safety Executive. A Guide to Risk Assessment Requirements: Common Provisions in Health and Safety Law. HSE Books. 2002.

34. Health Services Advisory Committee. Safe Working and the Prevention of Infection in Clinical Laboratories and Similar Facilities. HSE Books. 2003.

35. British Standards Institution (BSI). BS EN12469 - Biotechnology - performance criteria for microbiological safety cabinets. 2000.

36. British Standards Institution (BSI). BS 5726:2005 - Microbiological safety cabinets. Information to be supplied by the purchaser and to the vendor and to the installer, and siting and use of cabinets. Recommendations and guidance. 24-3-2005. p. 1-14

37. Allen BW. Survival of tubercle bacilli in heat-fixed sputum smears. J Clin Pathol 1981;34:719-22.

38. Baron EJ, Miller JM, Weinstein MP, Richter SS, Gilligan PH, Thomson RB, Jr., et al. A Guide to Utilization of the Microbiology Laboratory for Diagnosis of Infectious Diseases: 2013 Recommendations by the Infectious Diseases Society of America (IDSA) and the American Society for Microbiology (ASM). Clin Infect Dis 2013;57:e22-e121.

39. Rishmawi N, Ghneim R, Kattan R, Ghneim R, Zoughbi M, Abu-Diab A, et al. Survival of fastidious and nonfastidious aerobic bacteria in three bacterial transport swab systems. J Clin Microbiol 2007;45:1278-83.

40. Barber S, Lawson PJ, Grove DI. Evaluation of bacteriological transport swabs. Pathology 1998;30:179-82.

41. Van Horn KG, Audette CD, Sebeck D, Tucker KA. Comparison of the Copan ESwab system with two Amies agar swab transport systems for maintenance of microorganism viability. J Clin Microbiol 2008;46:1655-8.

42. Nys S, Vijgen S, Magerman K, Cartuyvels R. Comparison of Copan eSwab with the Copan Venturi Transystem for the quantitative survival of *Escherichia coli, Streptococcus agalactiae* and *Candida albicans*. Eur J Clin Microbiol Infect Dis 2010;29:453-6.

43. Tano E, Melhus A. Evaluation of three swab transport systems for the maintenance of clinically important bacteria in simulated mono- and polymicrobial samples. APMIS 2011;119:198-203.

44. Isenberg HD, Washington JA II, Doern GV, Amsterdam D. Specimen collection and handling. In: Balows A, Hausler WJ J, Herrmann KL, Isenberg HD, Shadomy HJ, editors. Manual of Clinical Microbiology. 5th ed. Washington D.C.: American Society for Microbiology; 1991. p. 15-28.

45. Fenton P. Laboratory diagnosis of peritonitis in patients undergoing continuous ambulatory peritoneal dialysis. J Clin Pathol 1982;35:1181-4.

46. Public Health England. Laboratory Reporting to Public Health England: A Guide for Diagnostic Laboratories. 2013. p. 1-37.

47. Department of Health. Health Protection Legislation (England) Guidance. 2010. p. 1-112.

48. Scottish Government. Public Health (Scotland) Act. 2008 (as amended).

49. Scottish Government. Public Health etc. (Scotland) Act 2008. Implementation of Part 2: Notifiable Diseases, Organisms and Health Risk States. 2009.

50. The Welsh Assembly Government. Health Protection Legislation (Wales) Guidance. 2010.

51. Home Office. Public Health Act (Northern Ireland) 1967 Chapter 36. 1967 (as amended).