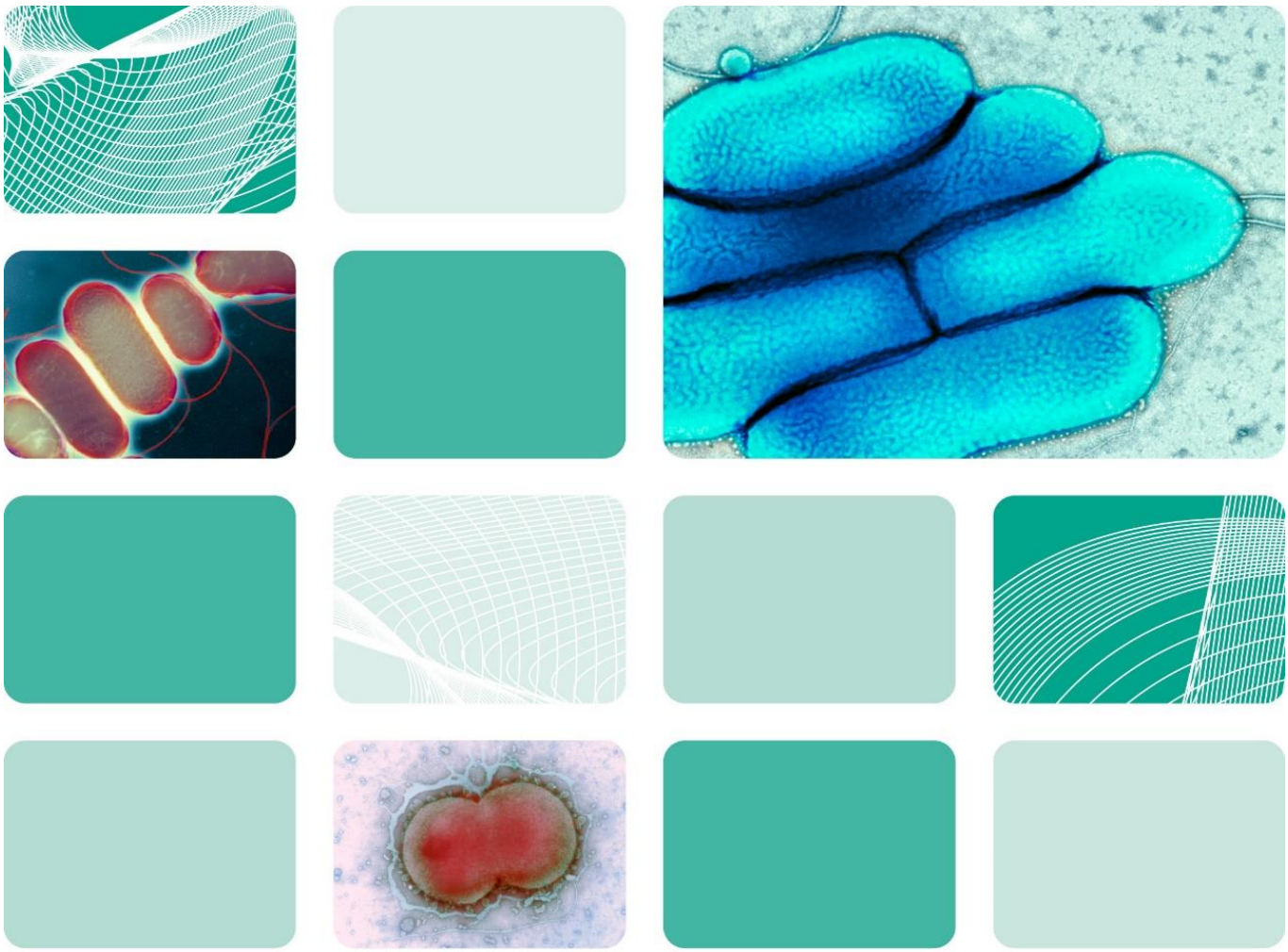
UK Health Security Agency

UK Standards for Microbiology Investigations

Investigation of cerebrospinal fluid shunts



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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.

The contributions of many individuals in clinical, specialist and reference laboratories who have provided information and comments during the development of this document are acknowledged. We are grateful to the medical editors for editing the medical content.

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	10/17.10.25
Issue number discarded	6.1
Insert issue number	6.2
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 12/06/2015.** 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. Section on ‘Public health responsibilities of diagnostic laboratories’ added.

Amendment No/Date.	9/**Error! Reference source not found.**
Issue no. discarded.	6
Insert Issue no.	**Error! Reference source not found.**
Section(s) involved	**Amendment**
Appendix.	Incubation time for fastidious anaerobe agar changed to 10 days.

Amendment No/Date.	8/18.05.15
Issue no. discarded.	5.2
Insert Issue no.	6
Section(s) involved	**Amendment**
Whole document.	Hyperlinks updated to gov.uk.
Page 2.	Updated logos added.
Types of specimen	List of specimen types compressed.
Introduction.	Contents displayed in bullet points rearranged in to prevalence order.
Technical information/limitations.	Section expanded.
Section 2.5.3.	Tables amended to include specimen type.
Appendix.	Flowchart presentation amended to look more similar to the contents of the table.
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

Cerebrospinal fluid shunt, shunt tubing, pus

This UK SMI describes the processing and bacteriological investigation of cerebrospinal fluid shunts.

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

4 Introduction

4.1 Hydrocephalus

Hydrocephalus is a condition caused by the accumulation of excess cerebrospinal fluid (CSF) within the cerebral ventricular system[1]. It occurs in both adults and children. If untreated, the prognosis is poor. It may be classified as[2]:

- communicating (no block between the ventricles and subarachnoid space)
- non-communicating (a block is present between the ventricles and subarachnoid space)

The common causes of hydrocephalus are an obstruction of the flow of CSF or a failure to absorb it, resulting from, in order of prevalence:

- major developmental abnormalities such as spina bifida
- meningitis
- perinatal haemorrhage
- trauma
- tumours, especially in the posterior fossa
- normal pressure hydrocephalus, a form of reversible dementia affecting the elderly
- overproduction of CSF

Treatment for hydrocephalus involves diverting CSF from the ventricular system to another compartment where it can be absorbed directly or indirectly into the bloodstream. This is done by means of a shunt. There is a risk of infection at the initial shunt insertion and at each subsequent insertion, and shunts may also be infected at other times.

4.2 Shunts

Shunts consist of drainage tubes incorporating one or more valves to control the direction and rate of CSF flow[2]. The devices may also incorporate a reservoir. There are two main types of shunt[2]:

- ventriculo-atrial (VA) shunts are used to drain CSF from the ventricle to the right atrium
- ventriculo-peritoneal (VP) shunts are more commonly used in contemporary neurosurgical practice; in these, the route of drainage is from the ventricle to the peritoneal cavity

Shunt replacement is necessary from time to time due to growth of the recipient or to mechanical obstruction or infection of the device.

If a shunt has to be removed because of infection, CSF drainage has to be maintained. This can be achieved by means of an implanted reservoir (which can be tapped as required) or by an external ventricular drain (EVD). These systems allow instillation of intrathecal antibiotics to treat ventriculitis before implantation of a new shunt. They may themselves become secondarily infected. These systems are also used to relieve hydrocephalus in the short term in patients who may not require a permanent shunt.

CSF shunts become infected by the following routes, in order of significance:

- organisms directly colonise the shunt, usually at the time of surgery
- organisms travel along the shunt by retrograde spread
- organisms reach the CSF and the shunt via haematogenous spread

Indicators of infection differ according to the type of shunt. For instance:

- signs of VA and VP shunt malfunction (and/or meningitis) include symptoms such as headaches, vomiting, drowsiness and decreased level of consciousness, with or without fever
- infected VA shunts discharge organisms directly into the right cardiac atrium. This gives rise to intermittent fevers and signs of bacteraemia. Rarely, shunt nephritis may occur a long time (sometimes several years) after initial shunt surgery. It is a result of the formation and deposition of immune complexes on the glomeruli basement membranes, and is seen only in VA shunts
- infected VP shunts discharge organisms directly into the peritoneal cavity, or may become distally infected without causing meningitis. Abdominal pain as a result of local inflammation may occur, as may local erythema over the shunt track. Rarely, the distal portion of the shunt may perforate the bowel, leading to peritonitis and abscess formation. Sometimes in such cases, polymicrobial ventriculitis, including anaerobes, can be found

Peritoneal fluid may be sent for culture if there is evidence of peritoneal inflammation. Mixed infections, particularly if colonic anaerobic bacteria are present, suggest bowel perforation.

Shunts which are removed should be sent for culture. Shunt infections may be confirmed by recovering the organism from blood cultures (see UK SMI S 12 – Sepsis and systemic or disseminated infections), CSF (see UK SMI B 27 - Investigation of

cerebrospinal fluid), shunt tubing, valves or a combination of these. It should be remembered that CSF microscopy may be unremarkable in shunt infection.

Intraventricular catheterisation (or external ventricular drainage) is used to monitor intracranial pressure in a variety of neurological and neurosurgical disorders, especially trauma[3]. Catheters used for this purpose may also be sent for culture (see UK SMI B 20 - Investigation of intravascular cannulae and associated specimens). Recently intracranial pressure 'bolts' have been introduced: this reduces the need for more invasive ventricular catheterisation in many patients.

Organisms isolated from CSF shunts and ventricular catheters include the following with coagulase negative staphylococci being the most common[2,4]:

- coagulase negative staphylococci
- *Staphylococcus aureus*
- enterobacteriaceae
- coryneforms and *Propionibacterium* species
- enterococci
- pseudomonads
- streptococci
- yeasts
- *Mycobacterium* species

The staphylococci amount for 60-85% of infections. *P. acnes* has been found in about 10% of shunt infections but usually only after prolonged anaerobic incubation. External ventricular drainage infections are also caused mainly by staphylococci but there is often a larger proportion of Gram negative bacteria including *Acinetobacter* species.

Organisms which may be isolated but less frequently include anaerobes and fungi other than yeasts[5-8].

The usual community-acquired bacteria (*Haemophilus influenza, Neisseria meningitidis* and *Streptococcus pneumoniae*, can cause meningitis in patients with shunts but they do not usually cause shunt infections, and the meningitis should be treated without removal of the shunt unless it is malfunctioning.

Biofilms have been shown to be a problem when dealing with shunt infections and can cause delays in the effect of treatment[9,10]. CSF results are of questionable value when biofilm infections are involved. Some bacteria are more prone to form biofilms than others[10,11].

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[12,13]

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[12-28]

6.1 Specimen collection, transport and storage[12-17]

Use aseptic technique.

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

Compliance with postal, transport and storage regulations is essential.

6.2 Specimen processing[12-28]

Containment Level 2 unless infection with a) *N. meningitidis,* b) a Hazard group 3 organism or c) TSE is suspected.

a) Although *N. meningitidis* is in Hazard group 2, suspected and known isolates of *N. meningitidis* should always be handled in a microbiological safety cabinet. Sometimes the nature of the work may dictate that full containment level 3 conditions should be used eg for the propagation of *N. meningitidis* in order to comply with COSHH 2004 Schedule 3 (4e).

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

c) If TSE is suspected, laboratory policies that take into account the local risk assessments may dictate that the use of a microbiological safety cabinet should be used when dispensing the specimen. Check recent ACDP guidelines on this area.

Laboratory procedures that give rise to infectious aerosols must be conducted in a microbiological safety cabinet[20].

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[29]. 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

Cerebrospinal fluid shunt, shunt tubing, pus

7.2 Optimal time of specimen collection[30]

For safety considerations refer to Section 6.1.

Collect specimens before antimicrobial therapy where possible[30].

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

When a shunt is removed all three portions should be sent in separate microbiologically approved containers of the appropriate size[13]. This will include the proximal catheter, a valve or reservoir, and a distal catheter[31]. CSF is usually obtained from the shunt reservoir and sent concurrently for investigation (see UK SMI B 27 – Investigation of cerebrospinal fluid).

7.3 Adequate quantity and appropriate number of specimens[30]

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

8 Specimen transport and storage[12,13]

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[30].

If processing is delayed, refrigeration is preferable to storage at ambient temperature[30].

9 Specimen processing/procedure[12,13]

9.1 Test selection

Microscopy and culture should be carried out as outlined below.

9.2 Appearance

Look for pus on external surface.

9.3 Sample preparation

For safety considerations refer to Section 6.2.

9.3.1 Pre-treatment

If the whole shunt is received intact, separate and process each portion separately.

If shunt tubing is received, cut a 5cm length aseptically from each end.

If CSF is visible in the shunt tubing or reservoir, aspirate it with a sterile pipette and process accordingly (see UK SMI B 27 - Investigation of cerebrospinal fluid). It is important to record the section from which the CSF is withdrawn to assist in deciding the aetiology of the infection and significance of isolates obtained.

If no CSF in the reservoir flush the tubing with sterile saline and collect fluid in a CE Marked leak proof container in a sealed plastic bag. In the absence of CSF sample this can be used.

9.3.2 Specimen processing

Pus

Swab any visible pus on the surface of the tubing[31].

(Process separately from the flushed tubing - see below).

Inoculate each agar plate with swab (see UK SMI Q 5 - Inoculation of culture media for bacteriology).

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

Tubing

Using a sterile pipette inoculate each agar plate with the uncentrifuged, flushed saline (see UK SMI Q 5 - Inoculation of culture media for bacteriology).

Note: The use of broth medium for processing shunt tubing can lead to false positive results and is not recommended[31].

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

9.4 Microscopy

9.4.1 Standard

UK SMI TP 39 - Staining procedures

Fluids

Any fluid aspirated from shunt tubing or other component is treated as CSF (see UK SMI B 27 - Investigation of cerebrospinal fluid).

Pus (from external surfaces)

Prepare a thin smear on a clean microscope slide for Gram staining.

9.4.2 Supplementary

N/A

9.5 Culture and investigation

9.5.1 Culture media, conditions and organisms

Clinical details/ conditions	Specimen	Standard media	Incubation			Cultures read	Target organism(s)
			Temp °C	Atmos	Time		
Shunt infection	Cerebrospinal fluid shunt, shunt tubing, pus	Chocolate agar	35-37	5-10% CO_2	40-48hr	daily	Any organism
		Blood agar	35-37	5-10% CO_2	40-48hr	daily	
		Fastidious anaerobe agar	35-37	anaerobic	10d[32]	≥40hr, 5d and at 10 days if you have an anaerobic cabinet otherwise at 10 days	Anaerobes
For these situations, add the following:							
Clinical details/ conditions	**Specimen**	**Optional media**	**Incubation**			**Cultures read**	**Target organism(s)**
			Temp °C	**Atmos**	**Time**		
If fungi are seen on microscopy	Cerebrospinal fluid shunt, shunt tubing, pus	Sabouraud agar	35-37	air	40-48hr	≥40hr*	Yeasts Fungi
*incubation may be extended to 10 days; in such cases plates should be read at ≥40hr and then left in the incubator/cabinet until day 10. If using jars then the first reading should be at 5 days. Certain opportunistic pathogens will require extended incubation. Laboratories should take precautions to stop plates drying out.							

9.6 Identification

Refer to individual SMIs for organism identification.

9.6.1 Minimum level of identification in the laboratory

Anaerobes	species level
β-haemolytic streptococci	Lancefield group level
Coagulase negative staphylococci	"coagulase negative" level
All other organisms	species level if in pure culture or clinically indicated

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

It may be useful to store coagulase negative staphylococci in case it is necessary to distinguish re-infections from relapsed infections.

9.7 Antimicrobial susceptibility testing

Refer to British Society for Antimicrobial Chemotherapy (BSAC) and/or EUCAST guidelines.

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

Report microscopy on the CSF (see UK SMI B 27 - Investigation of cerebrospinal fluid), or pus from external surface.

10.1.1 Microscopy reporting time

Urgent microscopy results to be telephoned or sent electronically.

10.2 Culture

Report organisms isolated or

Report absence of growth.

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[33,34] or equivalent in the devolved administrations[35-38]

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[35,36], Wales[37] and Northern Ireland[38].

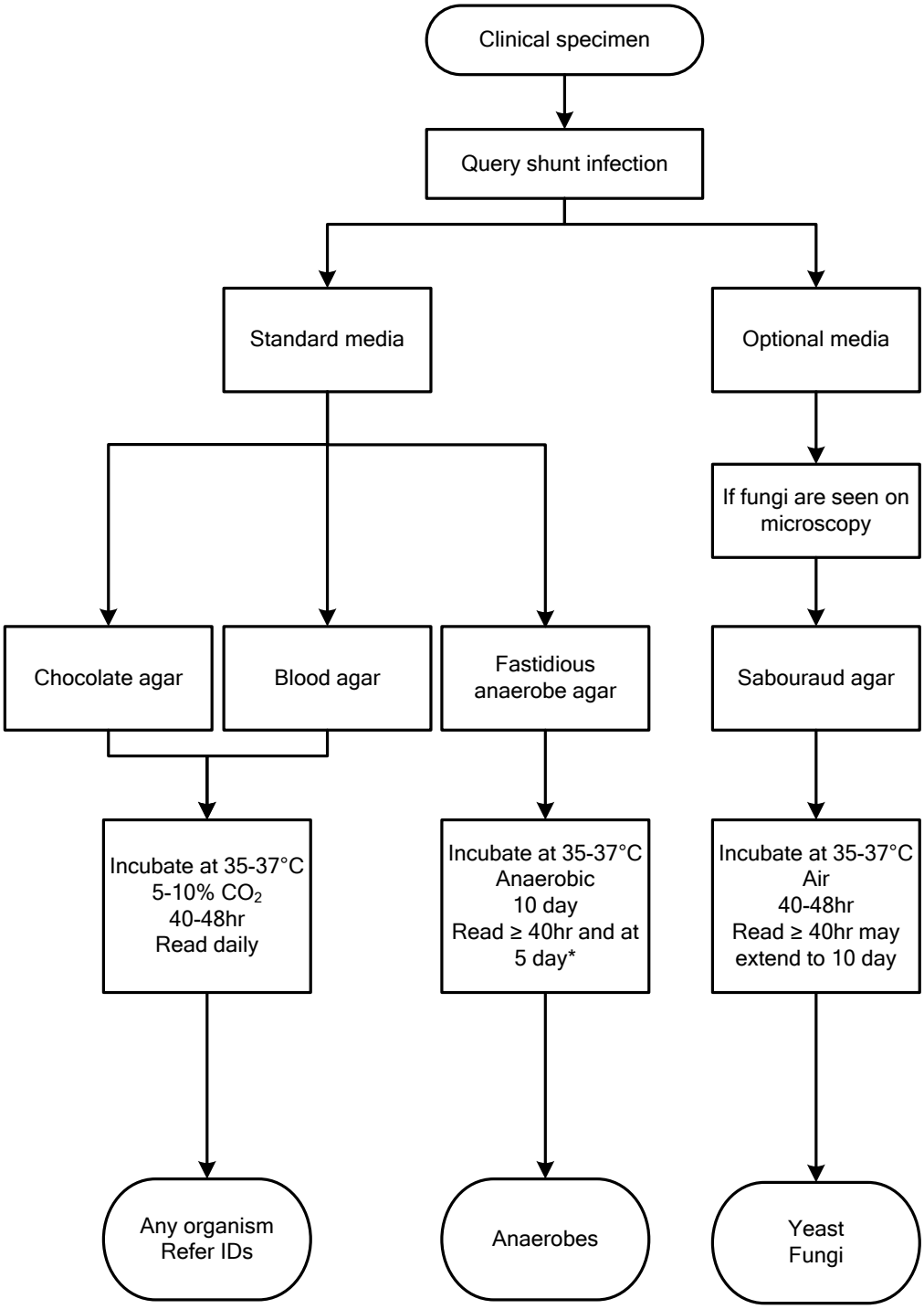
12 Public health responsibilities of diagnostic laboratories

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 cerebrospinal fluid shunts



*if using an anaerobic incubator/cabinet. Otherwise, the first reading should be at 5 days

References

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

1. Khan AA, Jabbar A, Banerjee A, Hinchley G. Cerebrospinal shunt malfunction: recognition and emergency management. Br J Hosp Med (Lond) 2007;68:651-5.

2. Gardner P, Leipzig T, Phillips P. Infections of central nervous system shunts. Med Clin North Am 1985;69:297-314.

3. Mayhall CG, Archer NH, Lamb VA, Spadora AC, Baggett JW, Ward JD, et al. Ventriculostomy-related infections. A prospective epidemiologic study. N Engl J Med 1984;310:553-9.

4. Sampedro MF, Patel R. Infections associated with long-term prosthetic devices. Infect Dis Clin North Am 2007;21:785-819, x.

5. Setz U, Frank U, Anding K, Garbe A, Daschner FD. Shunt nephritis associated with Propionibacterium acnes. Infection 1994;22:99-101.

6. Garbarini-Maywood C, Mulligan ME. Ventriculoperitoneal shunt infection due to anaerobic and facultative bacteria: case report. Clin Infect Dis 1995;20 Suppl 2:S240-S241.

7. Sanchez-Portocarrero J, Martin-Rabadan P, Saldana CJ, Perez-Cecilia E. Candida cerebrospinal fluid shunt infection. Report of two new cases and review of the literature. Diagn Microbiol Infect Dis 1994;20:33-40.

8. Chiou CC, Wong TT, Lin HH, Hwang B, Tang RB, Wu KG, et al. Fungal infection of ventriculoperitoneal shunts in children. Clin Infect Dis 1994;19:1049-53.

9. Bayston R, Ashraf W, Barker-Davies R, Tucker E, Clement R, Clayton J, et al. Biofilm formation by Propionibacterium acnes on biomaterials in vitro and in vivo: impact on diagnosis and treatment. J Biomed Mater Res A 2007;81:705-9.

10. Fux CA, Quigley M, Worel AM, Post C, Zimmerli S, Ehrlich G, et al. Biofilm-related infections of cerebrospinal fluid shunts. Clin Microbiol Infect 2006;12:331-7.

11. Stevens NT, Greene CM, O'Gara JP, Bayston R, Sattar MT, Farrell M, et al. Ventriculoperitoneal shunt-related infections caused by Staphylococcus epidermidis: pathogenesis and implications for treatment. Br J Neurosurg 2012;26:792-7.

12. 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".

13. 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.

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

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

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

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

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

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

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

21. 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.

22. 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.

23. 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.

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

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

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

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

28. 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

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

30. 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.

31. Bayston R. Diagnosis of shunt infection: Laboratory Procedures. In: Bayston R, editor. Hydrocephalus Shunt Infections. London: Chapman and Hall; 1989. p. 71-8.

32. Arnell K, Cesarini K, Lagerqvist-Widh A, Wester T, Sjolin J. Cerebrospinal fluid shunt infections in children over a 13-year period: anaerobic cultures and comparison of clinical signs of infection with Propionibacterium acnes and with oter bacteria. J Neurosurg Pediatr 2008;1:366-72.

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

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

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

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

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

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