Laboratories

73

Abstract

Patient test samples are taken and examined at outpatient clinics, in bed posts and at policlinic consultations and treatment units. They are collected and transported to central laboratories or examined by smaller laboratory units, adapted to the patient group. Samples are sent in pipes or transported by defined methods to the laboratory. A large number of samples are also sent to other hospitals, laboratories or diverse private laboratories.

The following chapter is focused on laboratory safety for patients and personnel to avoid spread of infections between patients, personnel and environment.

Keywords

Laboratory tests · Safety · Blood-borne infections · Sampling · Storage · Transport Control · Hygiene

73.1 Purpose

Protect staff, patients, other persons and the environment against infection [1–10].

73.2 Comprise

- All who work with patient testing, sampling, transport and investigation.
- All who work with further examinations of organic test samples from patients.
- Anyone who otherwise handles organic and/or biological material.

B. M. Andersen, *Prevention and Control of Infections in Hospitals*,
https://doi.org/10.1007/978-3-319-99921-0_73

73.3 Responsibility

The hospital's management provides written procedures and resources for proper handling of sample materials and other organic material, and that personnel, patients and visitors are not exposed to infection [1, 2].

The department's management provides for hygienic guidelines and training of personnel and to report to the Director in case of laboratory activities that may expose personnel and patients to infection.

Personnel follow guidelines for personal and general infection protection and report accidents or injuries that expose patients or personnel to infection.

73.4 Practical Measures [11, 12]

Patient samples often pass multiple links, from when they are taken to when they are analysed and destroyed. The entire sampling-packaging-transport-analysis-waste system must be ensured so that patients, personnel, others and the environment are not infected [1, 2, 5, 6].

73.4.1 Sampling from the Patients in the Wards

- The patient should be informed and placed at ease, and there should be peace and quiet during the procedure.
- Personal good hygiene, clean work clothes—not jewellery or personal clothing, and carry out good hand hygiene before and after testing/sampling from patients.
- Wear gloves and gown/surgical mask/shield/cap in case of a risk of splash and spill.
- Perform spot disinfection if spill of organic materials; wear gloves when disinfecting.
- Avoid storing of sampling equipment in patient rooms and do not place the "sampling basket" in the patient's bed.
- Wash or clean stasis hose, etc. with alcohol between each use.
- Fixed routines for cleaning of sample trolley/sample basket—once per week.
- Do not place the sampling equipment in the textile store or room for sterile equipment!
- In case of infection, the hospital's isolation regimes and procedures are followed.
- If any questions, contact the responsible head of the ward *before* going to the patient.

73.4.2 Laboratory Work: Personal Infection Protection

- Follow the laboratory procedures and regulations.
- Always wear gloves on contact with biological material.

- It is not allowed to eat, drink or smoke in the laboratory! Mouth piping is forbidden!
- Hand hygiene after use of gloves/contact with biological agent.
- Hand hygiene before leaving the laboratory and before food break.
- Change clothes if contaminated with biological material, new outfits every day.
- Do not eat in the same clothes as you work in, eventually use an "eating/pause gown" over laboratory clothes.
- Do not pour biological material from pipes or glasses; use pipette.
- Avoid spills and splashes! Think about what you do and work calmly!
- If spills, splashes and aerosols of biological material are expected/risk:
  - Work in a separate exhaust hood with gloves and gown
  - Or if exhaust hood is not present, work with gloves, surgical mask/cap, eye protection and single-use gown in a separate room with negative pressure.
- Carefully follow the instructions for routine cleaning of equipment.
- Avoid equipment where blood must be wiped away manually between each sample!
- If such equipment is still in use, protect hands with gloves, practise good hygiene and use eventually surgical mask/cap/eye protection (risk of aerosols).
- Provide instructions placed on safety benches, doors of rooms with higher risk of infection, centrifuges, etc.
- All equipment must be disinfected regularly. Make routines for this.
- All equipment must be disinfected before repairs. If this cannot be done, it must follow the guidelines for handling/personal protection during repair.

73.4.3 Workplace Functions in Laboratory

The laboratory should be spacious with proper placement of doors, exhaustion hoods and other major equipment in relation to ventilation requirements and working procedures.

- *Reception for samples* with registration and distribution of samples must be adapted to a level of hygiene that also takes care of unknown infection.
- *Division of samples* into separate tubes/glasses, by opening primary samples, should take place under the exhaustion hood/shield with gloves, gown and optional surgical mask/cap.

Note: Special treatment of rare types of risk samples, special microbes (Biosafety Laboratory 3–4).

Regular laboratory with good control over procedures must meet the following requirements:

- Hand wash and hand disinfection on all sections.
- Note! There should be *hot water* in the wash basin! At tapping, the temperature should reach 75 °C to avoid biofilm formation and growth of legionella and gram-negative environmental microbes.

- Good distance, at least 2 m between each workplace to avoid cross-infection (aerosol).
- Benches shall be easily washable and withstand disinfectants like 5% chloramine.
- Centrifuges should be in separate technical rooms, separate from regular laboratory work to prevent accidents (aerosol). Alternatively, place in exhaustion hood with negative pressure and at a good distance from workplace.
- Washing centrifuges should be treated in the same way.
- All fixtures must be washable and withstand disinfectants such as chloramine, including chairs. Textile-covered chairs are not suitable for laboratories.
- *Wastewater* from laboratory analysers should be treated as infected waste.

Risk laboratories/rooms where the risk of infection is greater than elsewhere (aerosol-forming procedures, known infection, work with specific pathogenic viruses or bacteria, autopsy, etc.).

- Limited access, interlocking doors that open the right way and with clear warning sign on the door.
- Negative air pressure with pressure gauge (25–70 pascal) and controlled airflow against separate extract via hepafilter/UVC/electrostatic filter.
- A separate decontamination system and autoclave for the destruction of contaminated waste and water/liquids, if necessary.
- Sluice function with the possibility of high-level personal protective equipment and a decontamination unit after work in the laboratory.
- Dedicated personnel, trained in and understanding the importance of high-risk mitigation and infection protection.

Service room with disinfection room, autoclave room, waste room, laundry room, clean storage, storage for samples, media, and other equipment; toilet, shower and washbasins, office, rest room, etc. must be carefully planned for each laboratory.

Note! Carefully separate between unclean and clean areas in the laboratories using sluice systems or corridors.

Technical rooms are planned for technical equipment such as robots and centrifuges.

Waste room Human biological material and/or contaminants/microbes must be handled as potentially infectious. It can be disinfected or autoclaved at the laboratory before it is disposed of as ordinary waste. Particularly contaminated waste (e.g. from microbiological laboratory) must be destroyed before it leaves the section/department.

- Handwash in the waste room.
- The waste room must be under negative pressure and there should be floor drain for cleaning.
- Infectious waste should not be compressed if it has not been disinfected beforehand.

73.4.4 Cleaning in Laboratories

- Benches are washed daily with soap and water. Organic material is removed first with spot disinfection.
- Chloramine 5% has a good effect against viruses, fungi, bacteria and spores.
- Floors are washed daily in laboratories that are in daily use, as well as toilets. Waste of organic material is removed immediately by the person who is soiling on the floor; spot disinfection.
- Equipment, etc. should not stand on the floor, preventing cleaning.
- Sampling carts and similar equipment are cleaned daily.
- See chapter on room cleaning.

73.4.5 Spot Disinfection

It is usually only necessary to disinfect the area contaminated with biological material.

1. Spilled blood and other organic materials are removed using gloves and absorbent material. It is packaged and treated as hazardous waste.
2. Suitable disinfectant—like chloramine 5%—is applied on contaminated surfaces/equipment with cloth or sponge.
   Acting time:
   – 30 min (dried surface)
   – 60 min (dirty surface)

73.4.6 Transport of Biological/Organic Samples

Transport pipes should not be used in case of high risk of infection. There must be a negative air pressure in the system. Routines for cleaning of transport containers should be implemented; cleaned in a decontaminator once a week or more frequently if contaminated/spill. All paper material should be replaced. The transportation system should be gas disinfected once a year or more often if contaminated.

Manual transport should be performed with packaged sample material in containers that are cleaned in a decontaminator once a week. Samples should stand upright—opening up—during transport.

See Chap. 74 on transport of samples.

73.4.7 Accidents with Samples: Blood or Tissue

Accidents occur most often in connection with centrifugation, tube/glass opening, test tube crushing and sampling and procedures that may cause spills/stab wound/cut.

- Immediate action: see *accidents with blood—or tissue*
- Registration, corporate health service
- Accident registration for the laboratory for measures:
  - New equipment due to less risk
  - New work procedures to reduce risk

73.4.8 Prophylactic Measures for Specialty Laboratories

Local routines and guidelines should be made for each laboratory specialty (microbiology, pathology, clinical chemistry, blood bank, immunology, medical genetic).

73.5 Background Information

All biological material is considered to be potentially infectious and should be treated as such [1, 2, 5, 6].

Laboratory infections are well known.

- A survey of 4079 people infected at work at microbiological laboratories showed that 168 died of infection [13]. Dominant agents were *Brucella* sp., Q fever, hepatitis, typhoid fever, tularaemia and tuberculosis [13].
- In an English survey of 24,000 laboratory workers, 45 were infected with *Shigella* sp., 38 with hepatitis, 21 with tuberculosis and 1 with brucellosis [14].
- In 2012, a laboratory outbreak with a fatal course of meningococcal meningitis was reported in San Francisco [15]. This type of infection is rare today. Globally, in the period 1985–2001, 16 laboratories reported infections with *Neisseria meningitidis*, half of which were fatal.
- HIV and hepatitis C are newer microbes that represent a clear risk for laboratory personnel, as well as resistant mycobacteria. The SARS virus has been documented to have infected laboratory personnel, as well as *Sabia virus* and other high-pathogenic viruses despite alleged use of protective equipment. Current agents are also prions—infectious, resistant protein molecules.
- By 2015, 309 laboratory infections were published in 47 reports worldwide—reviewed by a group in Belgium [16]. Infections with *Salmonella* dominated; 42%, followed by *Brucella;* 40%, *Neisseria meningitidis* 4%, vaccinia virus 4%, *Francisella tularensis* 2%, Ebola and Marburg virus 2%, *E. coli* (O157: H7) 1%, *Mycobacterium* sp. 1%, *S. aureus* 1%, *Bacillus anthracis and Bacillus cereus* 1%, *Burkholderia pseudomallei and B. mallei* 1%, *Clostridium difficile* 1%, West Nile virus 1%, *Chlamydia psittaci* <1%, cowpox <1%, dengue virus <1%, leptospirosis <1%, SARS <1% and *Shigella sonnei* <1% [16].
  - The infection routes recorded in this material were 46% inhalation, 28% parenteral inoculation—cut injuries—20% oral infection and only 6% contact infection [16].

  - The main reason for infection was lack of compliance 73% (did not follow routines) and indifference/lack of knowledge 2%.
  - Bio-accidents were the cause of 24% of cases, hence technical error 8% and human error 93% [16].
- Laboratory infections are usually highly under-reported as they often cause mild symptoms [16].
- The study also showed that the staff perceived that accidents were associated with lack of experience, insufficient training, excessive workload, lack of knowledge about work risk, distraction in work and lack of respect for personal protection [16].

73.5.1 Risk of Infection

The accident hazards in laboratories are many, especially because *aerosols* are easy to generate in laboratory work [16–19]. Drop of bottles, agar plates with microbes, etc. have been investigated and generally show significant formation of aerosols [19]. It is well known that in the case of blood spills, most of it will be invisible aerosols or splashes [18]. This is important because bacteria, viruses and fungi can penetrate the mucous membranes of the upper respiratory tract and conjunctivae.

Risk work depends on the material and what to investigate. By "known" infection status, the personnel are most often carefully following preventive guidelines. If "unknown" infection status, it is easier to break the routines for personal preventive measures if no good general precautions are taken.

Risk situations are procedures that are especially known to cause infection to personnel.

- Sampling
- Opening of tubes/containers
- Distribution of samples
- Analyses of blood samples
- Work with blood cultures
- Resistance determination of microbes
- Aerosol-forming procedures (centrifugation, splash on distribution of samples, resistance studies, splash and stabbing at sampling, etc.) [16–19].

73.5.2 Spread of Infection

- Contact: direct, indirect, and contact with drops that fall onto the surface/equipment/textiles.
- Airborne: "dust", droplets (particles <10 μm), droplet nuclei and microscopic drops of blood, microbes and tissues. This is probably the most frequent and dangerous infection in the laboratory [16–19].
- Inoculation/puncture/stab: transmission of blood/tissue from one person to another; direct or indirect vie contaminated equipment, etc.

73.5.3 Safety/Security Cabinet

In case of known or suspected risk of infection, and in the case of possible aerosol-forming procedures, the laboratory work should be carried out in safety cabinet class I–III. Glass cabinet is often better and easier to keep clean than plastic. The location of the cabinet in the room is important, not too close to the door or to exterior wall.

Class I with hepafilter is a clean cabinet and provides good personal protection if the air extractor works satisfactorily. Hepafilter protects the exhaust duct from contaminants.

Class II with hepafilter and recirculated air in the cabinet provides good personal protection and also protection for the material in the cabinet (cell cultures, etc.).

Class III with hepafilter for intake and exhaustion of air and work through gloves connected to cabinet provides maximum protection. Used only at risk laboratories at particularly hazardous agents to public infections (Ebola, Lassa, Marburgvirus mm.). The cabinet is heavy to work in and requires training/competence.

73.5.4 Infection from High-Risk Laboratories

There have been a number of—probably more than 200 "leaks"—infectious agents from high-risk laboratories both in the United States and in Europe. In the United States, a congressional hearing was done in 2014 after a laboratory accident with anthrax, smallpox and a fatal bird flu virus. During the period 2008–2012, there were more than 1000 laboratory accidents in the United States—involving bacteria, viruses and toxins that could pose a bioterror threat to the population. In 2012, CDC documented 727 unfortunate laboratory events and 11 laboratory infections, including theft of microbiological agents.

In summer 2014, it was at Tulane Primate Research Center in Louisiana that laboratory studies were made for vaccine production on the highly virulent bacterium *Burkholderia pseudomallei*—first and foremost present in Australia and Asia [20, 21]. During the autumn 2014, it was discovered that four monkeys located outside the complex and far from the laboratory and not involved in the project were infected with this bacterium. At the same time, a man who was to investigate the cause of the spread of infection in the laboratory was infected [20].

In July 2014, CDC closed high-risk laboratories after accidents with bird flu virus and anthrax spores that were not inactivated before shipment to other laboratories [22]. There were more than 100 people exposed to infection, but no one became ill.

73.5.5 Transport and Shipment Risk

There is a very large shipment of human biological material and microbes in most countries in the world. Accidents can happen here as well. A Canada post office car crashed during transport between laboratories with samples containing among others anthrax, *E. coli*, *Salmonella*, tubercle bacteria and influenza virus [23].

References

1. Norwegian Directorate of Labour Inspection. Regulations on protection against exposure to biological factors (bacteria, viruses, fungi and more) in the workplace, 19 Dec 1997.
2. European Parliament and Council Directive 2000/54/EC of 18 September 2000 on the protection of workers from the risks related to exposure to biological agents at work.
3. Stratton C. Tuberculosis, infection control, and the microbiology laboratory. Infect Control Hosp Epidemiol. 1993;14:481–7.
4. Anonymous. Update: universal precautions for prevention of transmission of HIV, hepatitis B virus and other bloodborne pathogens in health care settings. MMWR. 1988;37:377–88.
5. Rutala WA, Weber DJ. Disinfection, sterilization, and control of hospital waste. In: Mandell, Douglas, and Bennetts principles and practice of infectious diseases, vol. 2. 8th ed. Philadelphia: Elsevier Churchill Livingstone; 2015. p. 3294–309.
6. Edmond MB, Wenzel RP. Infection prevention in the healthcare setting. In: Mandell, Douglas, and Bennets principles and practice of infectious diseases, vol. 2. 8th ed. Philadelphia: Elsevier Churchill Livingstone; 2015. p. 3286–93.
7. Digranes A, Haukenes G, Hovig B, Iveland H. Prevention of infections in laboratories for medical microbiology. Norway: Society of Medical Microbiology; 1989.
8. Bolyard EA, Tablan OC, Williams WW, Pearson ML, Shapiro CN, Deitchman SD, et al. Guideline for infection control in healthcare personnel, 1998. Infect Control Hosp Epidemiol. 1998;19:407–63.
9. Mahoney FJ, Stewart K, Hanxian H, Coleman A, Alter MJ. Progress towards the elimination of hepatitis B virus transmission among health care workers in the United States. Arch Intern Med. 1997;157:2601–5.
10. Lymer UB, Schutz A, Isaksson B. A descriptive study of blood exposure incidents among healthcare workers in a university hospital in Sweden. J Hosp Infect. 1997;35:223–35.
11. Andersen BM, Syversen G. Laboratories. In: Handbook in hygiene and infection control for hospitals. Oslo: Ullevål University Hospital; 2003. p. 458–65.
12. Andersen BM, Syversen G. Laboratories. In: Handbook in hygiene and infection control for hospitals. Oslo: Ullevål University Hospital; 2008. p. 639–45.
13. Pike RM. Laboratory-associated infections: summary and analysis of 3921 cases. Health Lab Sci. 1976;13:105–14.
14. Harrington JM, Shannon HS. Incidence of tuberculosis, hepatitis, brucellosis, and shigellosis in British medical laboratory workers. Br Med J. 1976;1:759–62.
15. Standen A. Lab accident at San Francisco VA leaves man dead of bacterial meningitis. KQED News, 2 May 2012.
16. Willemarck N, Van Vaerenbergh B, Descamps E, et al. Laboratory-acquired infections in Belgium (2007–2012). ISPWIV, February 2015.
17. Aintablian N, Walpita P, Sawyer MH. Detection of *Bordetella pertussis* and respiratory syncytial virus in air samples from hospital rooms. Infect Control Hosp Epidemiol. 1998;19:918–23.
18. Cole EC, Cook CE. Characterization of infectious aerosols in health care facilities: an aid to effective engineering controls and prevention strategies. Am J Infect Control. 1998;26:453–64.
19. Bennett A, Parks S. Microbial aerosol generation during laboratory accidents and subsequent risk assessment. J Appl Microbiol. 2006;100:658–63.
20. Willgress L. Safety fears after potentially deadly bacteria are accidentally released from high-security Louisiana research lab. Mail-Online, 2 March 2015.
21. Peacock SJ, Schweitzer HP, Dance DA, et al. Management of accidental laboratory exposure to *Burkholderia pseudomallei* and *B mallei*. Emerg Infect Dis. 2008;14:e2.
22. CDC lab incident: anthrax. CDC, Updated 19 July 2014.
23. Doyle P. FedEx truck carrying microbes crashes in Winnipeg. CBC News 3-7-5.