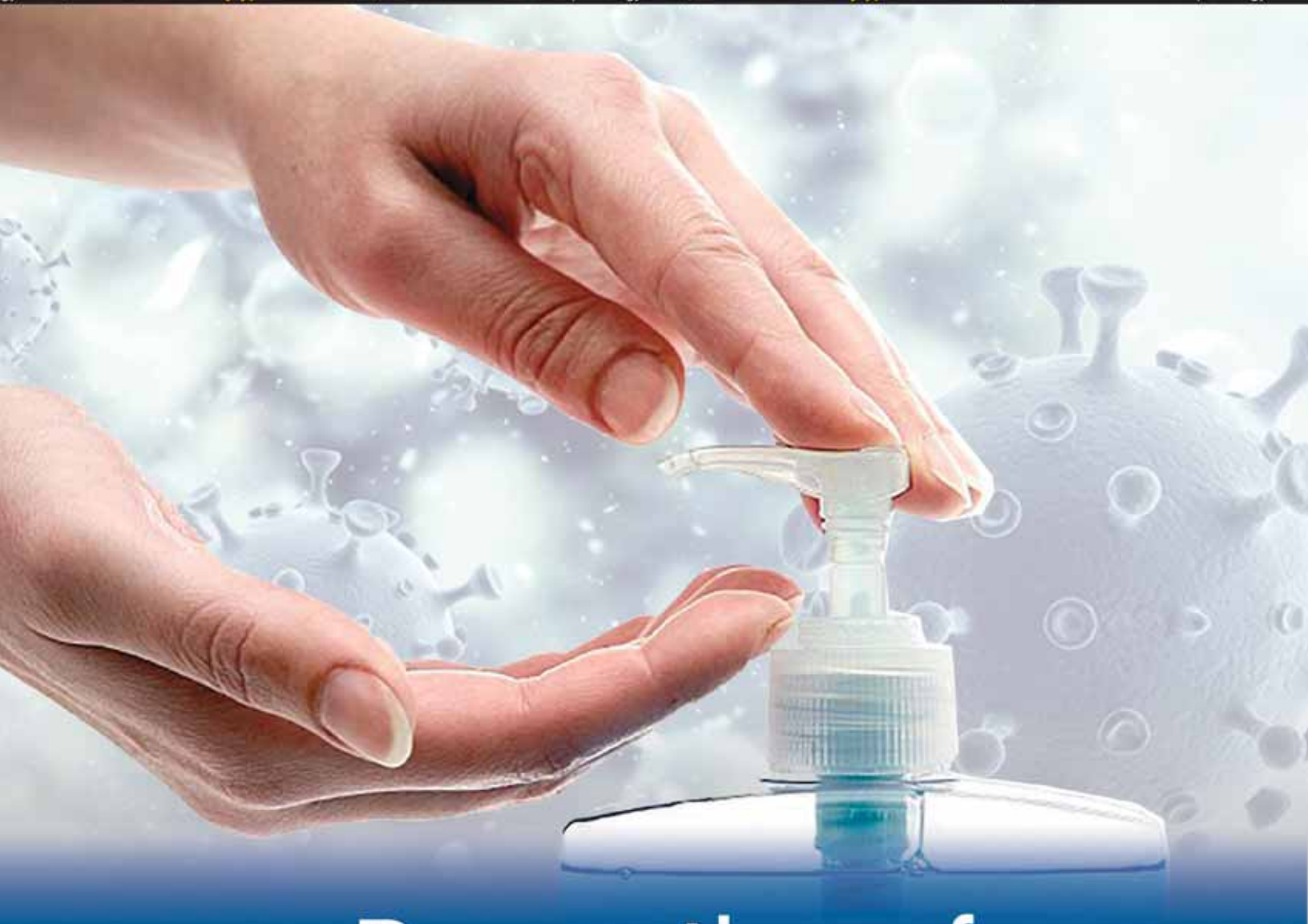
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Prevention of HEALTHCARE Associated Infections

Infection Prevention and Control

Usha Krishan Baveja
Yatin Mehta

Foreword
Naresh Trehan
Awarded Padma Bhushan and Padma Shri

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6

CHAPTER

Microbiology Laboratory Functioning and Role in Prevention and Control of Healthcare-associated Infections

Rumpa Saha

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Chapter Overview

- ❑ Objectives
- ❑ Introduction
- ❑ Role of microbiology laboratory in diagnostics
- ❑ Role: Conventional microbiological methods
- ❑ Newer microbiological methods: Role in rapid diagnostics
  - Nucleic acid detection based diagnostic technologies
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  - Microbial components as markers of infection
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- ❑ Quality assurance in microbiological laboratories
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OBJECTIVES

This chapter is to apprise the reader of the important role the microbiologist and microbiology laboratory play in the prevention and control of healthcare-associated infections (HCAIs). The reader will understand the role of microbiology in:

- Diagnosis of infectious diseases;
- Status of conventional methods;
- Value and use of newer techniques;
- Surrogate markers of infection;
- Role in antimicrobial stewardship, preparing antibiogram, and drafting antibiotic treatment guidelines;
- Role in surveillance, outbreak investigation, food and water safety;
- Role in detecting alert organisms, uncommon and newer bacteria.

INTRODUCTION

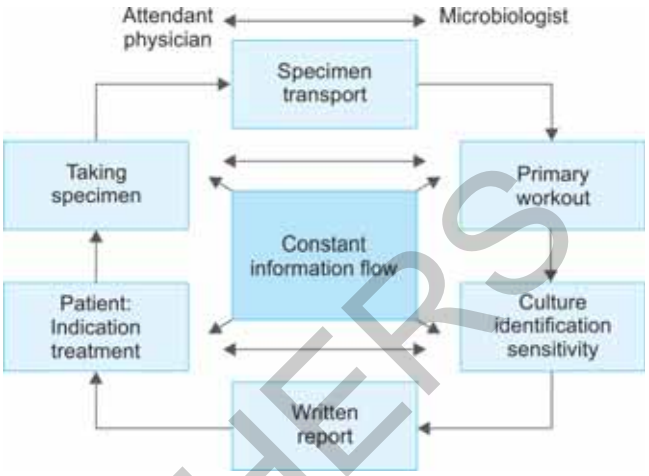
In the last one decade, revolutionary transformation in the sector of HCAIs in critically ill patients has been witnessed nationwide by contemporary medicine.[1] The best possible approach to achieve this is to sustain microbiology laboratories par excellence along with their serving hospital on the similar location, so that not only the doctors but also the general community can benefit from the necessary diagnostic tests. The resultant effect will also indirectly help to curb the menace of antimicrobial resistance (AMR).

The transmission of a pathogen from reservoir to a susceptible host through different vehicles is well explained in Chapter 1. A variety of associations in the sequence of disease acquisition sustain to keep the uninterrupted conduction of infectivity in the hospital environment. These include a reservoir of microorganism, susceptible host, and an environment/route for transmission. The commensal microorganisms can become opportunistic HCAIs pathogens. The reasons for this lie in the interactions between the constituents of the classical pathogenesis triangle [the "seed" (microbe), the "soil" (patient), and the "climate" (environment)]. For example, an intravenous cannula (a "climatic" factor) can provide the portal of entry for skin flora, e.g., coagulase-negative staphylococci, to cause a bloodstream infection. More vulnerable patients, e.g., the immunocompromised patient (a "soil" factor), are more prone to infections caused by commensal organisms such as *Candida* species.

Microbiologist and microbiology laboratory have two major roles in containment of HCAIs. One is providing early valid diagnostics for appropriate treatment and better patient outcomes by facilitating specific directed antibiotic therapy and antimicrobial stewardship and second is to participate in various activities (e.g., air, water and food safety, etc.) of infection control with the aim of reducing HCAIs.[1-3]

ROLE OF MICROBIOLOGY LABORATORY IN DIAGNOSTICS

Microbiologist ensures that the right sample from right site in right volume is collected at the right time with all the recommended aseptic precautions in the appropriate sterile container, is stored and transported following the correct environmental conditions (temperature, etc.). Microbiologist also trains the clinicians and staff on process of sample collection, storage, and transport for



FLOWCHART 1: Flow of information from microbiologist to the clinician.

various tests such as culture and antibiotic susceptibility, serology and rapid molecular tests, etc. The technologists are trained in criteria of acceptance or rejection of samples, so that adequate samples only are processed for diagnostics. Laboratory technicians follow good laboratory practices and follow the current guidelines of Clinical and Laboratory Standards Institute (CLSI) or the European Committee on Antimicrobial Susceptibility Testing (EUCAST) for conducting antibiotic susceptibility test and reading and interpreting the results effectively for patient care.

Since the microbiology laboratory's rapid and consistent identification of nosocomial pathogens is the keystone that serves as a source of expert consultation for clinicians and infection control personnel and patient management, there should be a constant communication between the attending doctor and the microbiologist at all stages of patient care including suggesting the preliminary diagnosis (**Flowchart 1**).

ROLE: CONVENTIONAL MICROBIOLOGICAL METHODS

Although some infectious diseases can be diagnosed clinically with the addition of some simple, rapid ward-based tests and treated empirically, it is still wise to also process specimens to confirm the diagnosis of the specific implicated pathogen, as well determining its antimicrobial susceptibility pattern for best patient outcomes.

Some infections must be treated without delay after clinical diagnosis with empiric antimicrobials (e.g., acute meningitis, sepsis, or severe pneumonia), but the

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clinician will also want the results of specimen analyses to establish the exact microbial etiology and need to de-escalate or switch to targeted antimicrobial therapy (antimicrobial stewardship), the information that only microbiology laboratory can provide.

Conventional microbiologic techniques do provide useful information to the treating physician. However, these cannot be totally relied upon for rapid and accurate identification of causative microorganism and their susceptibility pattern. Hence, the requirement for emergent rapid methods of diagnosis, rapid identification, and antimicrobial susceptibility testing requires the incorporation of sophisticated equipment and newer techniques in microbiology laboratories. Significant advancements made in the fields of equipment, reagents, and methods have made the microbiology more demanding as well as more accurate and more rewarding discipline.

Much research is being conducted currently to provide diagnostic laboratories with more rapid or point-of-care tests (POCTs) to know the exact etiology and institute correct therapy as quickly as possible, so that morbidity and mortality can be reduced, as well as enabling the switch to more targeted antimicrobial therapy to reduce the selection pressures that encourage the emergence of AMR.

One of the specific and important activities of care bundle practice for prevention of HCAIs is collection of appropriate sample before the start of broad-spectrum antibiotics and transport of same to the microbiology laboratory for early diagnosis of HCAIs such as central line-associated bloodstream infections (CLABSI), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infection (CAUTI). The bundle approach has helped to reduce HCAIs in the long run. The early institution of antibiotic susceptibility report-based specific directed treatment also helps to reduce development and subsequent transmission of multidrug-resistant microorganisms (MDROs). Choosing the most appropriate body site for obtaining specimen for culture is of utmost importance for quick microbiological analysis thus contributing to accurate therapeutic intervention by the clinician.

Rapid diagnostic tests are especially important in the diagnosis of HCAIs as HCAIs are mostly caused by MDROs, so early identification of etiological agents will help in appropriate empiric therapy. Moreover, defined clinical HCAIs syndromes, e.g., surgical site infections, can be caused by several microorganisms, as well as the same microorganism causing different HCAIs clinical syndromes. The correct etiological diagnosis and more targeted antimicrobial therapy will also lead to the earlier eradication of the infecting microorganisms and help to prevent the patient from continuing to be the source of microbial spread to other patients (i.e., the diagnostic role also comprises part of the laboratory's public health/epidemiological role). Use of conventional, time-consuming diagnostic methods by many microbiology laboratories leads to failure/delay in detection, identification, and antibiotic susceptibility testing of causative organism of sepsis and its management. The fact that up to half of the cultures from patients with a clinical diagnosis of sepsis are often negative adds to the confusion in diagnosis of sepsis.[4-6]

NEWER MICROBIOLOGICAL METHODS: ROLE IN RAPID DIAGNOSTICS

New diagnostics focused on culture-limited or culture-independent technologies for rapid, meaningful pathogen detection on-site, time-saving tests are given below:

Nucleic Acid Detection based Diagnostic Technologies

Nucleic acid detection based diagnostic technologies from signal positive blood culture bottles/serum/plasma include:

- Pathogen-specific polymerase chain reaction (PCR) assays, which target species/genus-specific genes;
- Broad-range PCR assays targeting conserved sequences in bacterial (*16S, 5S, 23S, rRNA* genes)/fungal (18S, 28S, rDNA) genome combined with sequencing/hybridization;
- Multiplex real-time PCR assays targeting ITS-1 and ITS-2 rRNA and rDNA allowing the rapid detection of different pathogens and simultaneously allowing quantization;
- Deoxyribonucleic acid (DNA) micro-arrays with resistant gene detection increase the specificity further. Use of Au/Ag nanoparticle probes and microarray for detection of bacterial pathogens, and several resistance markers help in immediate diagnosis in severe clinical conditions like sepsis with a turn-around time (TAT) in positive blood culture broth of <2½ hours. Use of automated systems for direct extraction of DNA/ribonucleic acid (RNA) reduces the TAT and is potential for better antimicrobial stewardship, clinical outcomes, and decreased hospital costs;

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- BioFire® FilmArray is a POCT using nested multiplex PCR with results in about 1 hour. It is Food and Drug Administration (FDA) approved and available in India also. At present, it has four test panels: Blood culture panel—detecting 24 bacteria, yeast, and three antibiotic resistant genes from signal positive blood culture broth; respiratory panel—detecting 20 respiratory viruses and bacteria in nasopharyngeal secretions; meningitis/encephalitis panel—from cerebrospinal fluid (CSF) directly and tests 14 most relevant bacteria, viruses, a yeast; gastrointestinal (GI) panel—which detects 22 common GI pathogens including viruses, bacteria, and protozoa from stool that cause infectious diarrhea.

Nonamplified Nucleic Acid Detection Based Assays

- *Fluorescent in situ hybridization (FISH)*: FISH test is of two types: The conventional method and the current new method. The conventional method uses the DNA oligonucleotide probes tagged with fluorescent dye to detect the target rRNA of bacteria and fungi directly in the specimen. The recent amended version of FISH is the peptide nucleic acid (PNA)-FISH that uses peptide nucleic acid probes to detect the target rRNA genes of bacteria and fungi in sample. Both methods target rRNA genes of bacteria or fungus but the latter (PNA-FISH) has more vigorous hybridization characteristics. PNA-FISH probes are also less vulnerable to inhibition due to organic matter and sample contamination. These methods are rapid diagnostic tools giving the result in 25 minutes. PNA-FISH is also a useful tool to promote antimicrobial stewardship;
- *Bacteriophage-based pathogen detection assays*: Either tagged phages/reporter phages are used to detect presence of both methicillin-sensitive *Staphylococcus aureus* (MSSA) and methicillin-resistant *Staphylococcus aureus* (MRSA) from positive blood cultures. The test has better effectiveness, increased sensitivity, and achieves detection in 5 hours. After successful trials, USFDA has approved microphage MRSA/MSSA blood culture test for detection of methicillin resistance in USA;
- Bioinformatics-based approach compared with bacterial fingerprinting such as MALDI-TOF (matrix-assisted laser desorption/ionization-time of flight) mass spectrometry (MS), which uses the proteomic profiles and antibiotic resistance indicators allowing a rapid diagnosis in 30 minutes. Chief disadvantage being inability to use on clinical samples directly. Cost is also a major constraint.

Microbial Components as Markers of Infection

Nonmolecular biomarkers available especially for detection of sepsis are:

- Detection of fungal Ag using galactomannan (GM)—*Aspergillus*-specific cell wall component for diagnosis of invasive aspergillosis;
- *(1-3)-b-D-glucan* (BG)—for invasive candidiasis and invasive aspergillosis.

Surrogate Biomarkers of Microbial Infection

Surrogate biomarkers of microbial infection are:

- *Procalcitonin*: Risk assessments for critically ill patients with sepsis;
- *Interleukin (IL)-6 and C-reactive protein*: Sentinel markers of inflammation and infection;
- *sTREM-1*: The soluble triggering receptor expressed on myeloid cells-1, a promising candidate to differentiate sepsis from systemic inflammatory response syndrome (SIRS).

QUALITY ASSURANCE IN MICROBIOLOGICAL LABORATORIES

Day-to-day practice of internal quality control is extremely important to produce valid, acceptable, and accurate results for all types of tests including bacteriology, serology, molecular biology, and immunology diagnostic tests. The standard reference materials are used to validate the test results. This has become extremely important keeping in view the advanced newer technologies being introduced and used in microbiology for diagnostics. Participation in external quality assurance programs is essential to rank the quality of performance of tests vis-à-vis that of other similar laboratories. There are national and international standards for quality performance in the microbiology laboratory. One such standard is ISO 15189:2012, which is accepted for medical laboratories in India by the National Accreditation Board for Laboratories (NABL) Board under Quality Council of India Accreditation by NABL using this standard helps to maintain daily internal quality control practices and produce valid results in the laboratory.

MICROBIOLOGY DATA: BASE FOR RISK ASSESSMENT AND PLANNING OF PREVENTIVE MEASURES

Microbiology laboratory produces periodic cumulative data (retrieved from LIS system or/manual collection) of bacteria isolated together with antimicrobial susceptibility data. These reports are stratified by ward,

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anatomical site, patient group, and pathogen. Such data are important as they show the burden of various microorganisms in different areas of the hospital along with the extent of AMR, local epidemiology together with the trends of specific pathogen and specific resistance, and a baseline incidence of particular microbes (MRSA, MDROs, etc.). Such reports are also locally important as a base for risk assessment to staff and planning of preventive measures.

MICROBIOLOGY LABORATORY SUPPORT IN ANTIMICROBIAL STEWARDSHIP

The fundamental responsibility of microbiology laboratory in antimicrobial stewardship endeavors to audit antibiotic recommendation in the interest of better patient outcomes. The antibiotic susceptibility report-based, directed treatment curtails potential drug toxicity, averts appearance of drug resistance, and reduces the healthcare costs. Role in antimicrobial stewardship starts with the choice of antimicrobials for laboratory susceptibility testing. The panel of antimicrobials should be decided after consultations with clinical teams and antimicrobial committee (team) and be based on periodic laboratory reports of antimicrobial susceptibilities of local isolates, stratified by pathogen, site of infection, and by unit/service (e.g., susceptibility of isolates in chronic dialysis service might not be the same as in a surgical ward). Such reports are very important for the design of hospital antimicrobial formulary and hospital guide for empiric and definitive therapies, restrictive antimicrobial use reporting, and other agreed upon interventions. The antibiotic susceptibility report helps in escalating/de-escalating antimicrobial agents. A medical microbiologist should usually be a member of antimicrobial stewardship committee and antimicrobial team.[7]

MICROBIOLOGY LABORATORY IN ACTIVE SURVEILLANCE CULTURES

Proactive focused surveillance either for a particular organism (e.g., MRSA) or an infection, e.g., CLABSI, is the method of choice as it is feasible and more efficient. Active surveillance cultures for alert organisms (including multidrug resistant) is practiced by many hospitals throughout the world. This is mainly admission screening for MRSA, extended-spectrum beta-lactamase (ESBL) Enterobacteriaceae, carbapenem-resistant Enterobacteriaceae (CRE), and vancomycin-resistant enterococci (VRE). While admission screening for MRSA is a part of many guidelines (rules vary), screening for other resistant bacteria is still under consideration in many countries/regions. This practice also varies in different hospitals depending on their local epidemiology and circumstances. The microbiology laboratory plays the essential role in this kind of surveillance, and can advise on the best media (including cheaper in-house media tailored to the local strains involved) and methods to be used and correct collection of the specimens. More rapid molecular methods may have a role to play, depending on the clinical scenarios, prevalence of the organisms, and cost-effectiveness of the method used.

Continuous supervision is the foundation for any infection control and antimicrobial stewardship program; the microbiology laboratory serves as an early warning system with active surveillance. Contribution by the clinicians by providing complete clinical and epidemiological data aids the laboratory in carrying out effective surveillance.

Alert Organism and Infection Condition Surveillance Systems

There should be daily listings made available for or urgent communication for alert organisms (multiantimicrobial resistance), rarer organisms with higher pathogenicity, or high epidemic propensity, or new organisms and new resistances in that hospital. Specific examples include: VRE, vancomycin intermediate *Staphylococcus aureus* (VISA), MDR *Acinetobacter baumannii*, MDR *Pseudomonas aeruginosa*, MDR *Mycobacterium tuberculosis*, extended spectrum beta-lactamase producers or CRE as well as agents of bioterrorism (anthrax bacillus) or any other organism that could be of interest locally.

Proactive surveillance for early detection of infection condition (CLABSI, CAUTI, VAE, VAP, and SSI) should be done for better patient outcomes. It can be laboratory report based or clinician opinion based.

MICROBIOLOGY LABORATORY IN CONTAINING AMR

Antimicrobial resistance is a global humanity and patient safety threat. The Global Health Security Agenda (GHSA) has kept the issue of AMR in their priority register. WHO has recommended that every WHO member country must prepare and implement a plan to contain (part of the WHO's Global Action Plan for

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AMR) the global menace of AMR. Various interventions in the microbiology laboratory aimed at preventing development of further drug resistance and spread of resistant microorganisms are:

- Proactive surveillance for new resistance development and transmission of AMR;
- Use of rapid diagnostic technologies for early and appropriate treatment of infections;
- Use of current guidelines for identification and antimicrobial susceptibility testing of causative microorganism;
- Quality assurance practices for performing tests and undergoing NABL accreditation;
- Development and implementation of local antibiogram-based treatment guidelines to prevent inappropriate use of antimicrobial agents;
- Regulation of prescription requirements;
- Development and implementation of antimicrobial stewardship program;
- Screening of new patients admitted to hospital for carrying drug resistant bacteria.

MICROBIOLOGY LABORATORY ROLE IN PREPARING ANTIBIOGRAM

Knowledge of local AMR pattern of isolates from different specimens collected from different locations of the hospital is critical for management of infectious diseases. The microbiology laboratory complies with CLSI and WHO guidance for creation of cumulative antibiogram. Antibiogram from local antibiotic susceptibility data of the hospitals prepared at least once a year or more frequently as per the hospital helps in following ways:

- It creates an information bank on types of organisms isolated from different specimens in different locations of the hospital (ICU, wards, post-transplant wards, emergency, postsurgical units, and so on). This information is extremely important for caregivers to plan empiric antibiotic treatment in different areas;
- Antibiogram helps in preparing local treatment guidelines;
- Antibiogram also facilitates monitoring changes in drug resistance and the regions where infection control team of the hospital needs to intervene;
- Antibiogram helps in tracking emergence of new drug-resistant organisms and their transmission in different areas of the hospital;
- It reports the status of drug resistance to management of the hospital and helps to formulate the appropriate, effective formulary based on this data;
- Antibiogram helps in formulating and implementing an active antimicrobial stewardship program based on local AMR data.[8]

The CLSI criterion for preparation of cumulative antibiogram includes the following six points:

1. Only the report on first isolate is included in the data for analysis. Duplicate isolates are excluded.
2. Antibiogram includes analysis of antibiotic susceptibility data of at least 1 year.
3. The organism susceptibility data included for analysis has to have at least 30 observation point (n >30/organism). In case the number of observations is less, include a foot note to explain the same or pool data on same organism from similar local hospitals or collect 2 years data of hospital on such organisms.
4. Report the sensitive and resistant strains of same organisms separately, e.g., MRSA and MSSA are analyzed separately.
5. Susceptibility data of strains of *Streptococcus pneumoniae* isolated from cases of meningitis and from other sources such as blood, pus, etc., are analyzed separately.
6. Only pathogen–drug test combinations recommended for routine or supplemental reporting are included.

However, the opinion and feedback of clinicians are indispensable for precision, preparation, and the adequate utilization of the antibiogram. Antibiogram is a prerequisite for preparing hospital antibiotic policy.[8]

MICROBIOLOGY ROLE IN PREPARING ANTIBIOTIC POLICY

The antibiogram prepared by the microbiologist, based on laboratory data, is the most important pillar for drafting the antibiotic treatment guidelines. Microbiologist is an important member of the team along with clinicians, clinical pharmacologist, and others to draft specialty and organism-wise treatment and antimicrobial prophylaxis guidelines.

ROLE OF LABORATORY IN DETECTION AND INVESTIGATION OF OUTBREAKS

The recognition and investigation of disease outbreaks is another major role of the microbiology laboratory. Atypical clusters of cases are by and large first detected by the microbiology laboratory from culture reports. However, to confirm the existence of an outbreak, typing

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of isolates needs to be done by the laboratory to find out the epidemiologically relatedness of the strains. This also helps to establish the mode of spread of the outbreak and assists in recognizing reservoirs and carriers. During this investigation, Infection Prevention and Control team must collaborate with the laboratory, as needed.

ROLE OF MICROBIOLOGY LABORATORY IN FOOD AND WATER SAFETY

Although routine microbiological food safety testing to keep consumers safe is not done by clinical or diagnostic microbiology laboratories, but testing of leftover food in case of food poisoning/gastroenteritis outbreaks can be performed to confirm diagnosis. However, as water can be a source of microbial contamination, water quality testing should be done routinely as per hospital policy. Fecal contamination of water can be detected by testing for coliforms. The most commonly used groups of indicator organisms include coliforms, thermotolerant coliforms, *Escherichia coli*, and enterococci. The enterococci are known to survive better in the environment and may therefore be an indicator for older fecal contamination. Hospital overhead tanks and water from drinking sources should be regularly analyzed by the microbiology laboratory for adequate prevention of HCAIs.

ROLE IN ENSURING PERSONNEL SAFETY

Microbiology plays an important role in ensuring personnel safety following needle stick injury, accidental exposure to blood and body fluids of patients. Testing of source material and exposed person is done by laboratory and appropriate management (postexposure prophylaxis) is done by designated physician, based on the laboratory results.

PREVENTION AND SURVEILLANCE OF LABORATORY-ACQUIRED INFECTIONS

The successful input of infection control team is supported by the ability of the laboratory staff to be acquainted with its hazards and protection/prevention from the same. Laboratory technologists are educated on the potential risks in the laboratory and practices and processes to avoid these risks. The practices include standard work precautions, hand hygiene, use of personal protective equipment (PPE), and following safe methods and techniques to prevent injury/harm to self and colleagues. The laboratory methods must be reliable and technologists must have good working knowledge of the techniques used, to meet high standards. The laboratory data must be retrievable and must provide information for prevention and surveillance of laboratory-acquired infections.

SUMMARY

For the prevention of HCAIs, the multifactorial role of microbiology laboratory may be summarized as accurate speciation and typing of isolated pathogen, rapid communication of reports to clinicians, preparation of antibiogram, ensuring water and food safety, participation in HCAI surveillance, participation in outbreak investigation and management, participation in AMR surveillance by proper monitoring and containment of AMR, education on HCAIs prevention of laboratory personnel and other healthcare workers.

Microbiologist is an important member of Infection Control Committee (ICC), Infection Control Team (ICT), and Antibiotic Committee (AC) and helps in drafting preventive strategies and treatment guidelines.

The microbiology laboratories are the first line to detect and help plan defense in the event of new emerging diseases as proven again in COVID-19 outbreak, containment of AMR, management of outbreaks of illness, and a bioterrorism attack.

The microbiology laboratory also is a crucial component of the infection control team responsible for preventing healthcare-associated infections, thus promoting good patient care outcomes.

GLOSSARY

- *PCR*: Polymerase chain reaction.
- *NAT*: Nucleic acid amplification testing.
- *CLSI*: The Clinical Laboratory Standards Institute.
- *EUCAST*: European Committee on Antimicrobial Susceptibility Testing.
- *POCT*: Point-of-care test.
- *TAT*: Turnaround time.
- *FISH*: Fluorescence-based in situ hybridization.

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Questions and Answers

1. The functions of microbiology laboratory include: (Tick the correct answer/s)—
   a. Carrying out culture of patient specimens
   b. Doing antibiotic susceptibility
   c. Ensuring cleaning of surfaces
   d. Managing spills of hazardous chemicals
   e. Infection control in ICUs
   (Correct answer/s: a and b)
2. Tick true or false against each statement:
   a. Antibiotic susceptibility report helps in antimicrobial stewardship ..... True/False
   b. De-escalation of antimicrobial is done on basis of laboratory report ..... True/False
   c. Microbiologist prepares antibiogram ..... True/False
   d. Critical alert organisms are detected in microbiology ..... True/False
   e. Microbiologist prescribes the antimicrobial treatment ..... True/False
3. The molecular-based diagnostic tests help in: (Tick the correct answer/s)—
   a. Rapid diagnosis of infection
   b. Detection of multidrug-resistant organisms
   c. Reducing turnaround time
   d. Reducing mortality
   e. All of the above
   (Correct answer/s: a, b, c, d, and e)
4. Define POCT. Name some POCTs you know of. How do POCTs help in patient safety?
5. Safety of an infected patient is assured by: (Tick the correct answer/s)—
   a. Rapid specific diagnosis
   b. Detection of high blood sugar
   c. Prescribing the right antimicrobial agent based on laboratory report
   d. Always treating any infection with broad-spectrum antibiotic
   e. All of the above
   (Correct answer/s: a, b, c, and e)

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Usha Krishan Baveja has worked as Professor and Senior Consultant Medical Microbiology. She taught microbiology to UGs, PGs, and PhDs at MAM College, New Delhi for more than two decades. She has been involved in providing diagnostic services in medical microbiology at MAM College, National Centre for Disease Control (NCDC), and Medanta the Medicity, Gurugram. As HOD and Director In-Charge NCDC, she was involved in investigating and managing outbreaks of infections, developing and implementing HIV diagnostics, quality assurance, and infection control across states in India (since 1995). She has worked as technical consultant for William J Clinton Foundation, India, UNICEF India, and World Bank HQ, Washington, DC. Dr Baveja is a recipient of various awards, has published books, scientific papers, and contributed various chapters to books. Dr Baveja continues to work for NABL, NABH, and serve as technical expert for various national programs like antimicrobial resistance and national AIDS control organization.

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