Welcome to Unit 10, Infection Control and the Microbiology Laboratory. This unit will focus on the relationship between Infection Control and the Microbiology Laboratory regarding infection prevention in healthcare facilities. (Another entire course PHC 6562 “Microbiology for Healthcare Workers” is devoted to microbiological principles and concepts.)

Remember back to Unit 1. Consultation to and from the Microbiology Laboratory is the second of six (6) additional IC functions essential in infection control programs. A large part of infection control practice is related to microbiology. Included in the application part of this consultation are how the laboratory contacts infection control, what situations require contact, panic values for organisms or serologic tests (e.g., meningococcal meningitis or a positive syphilis test), etc. Infection Preventionists need to know what tests the lab can perform, how to interpret these tests, and the right specimens and containers to use to send down a clinical specimen for microbiological testing, to name a few examples.

The Microbiology Laboratory has two main functions in the healthcare facility: one is diagnosis of infection in individual patients, directly related to patient care and the other is support to the healthcare-associated infection (HAI) prevention and control program. But the first role - diagnosis of infection - also has a function in healthcare-associated infection (HAI) prevention: if the etiological diagnosis of infection is rapid and accurate, the patient will be treated properly at the beginning of infection, so the time of transmitting microorganisms will be shorter. A microbiology laboratory should be set up inside the hospital, working every day on a 24 hour basis. If it is not possible, then the hospital should contract microbiology services with the geographically nearest laboratory. Every microbiology laboratory should have quality assurance procedures in place, and if possible, external quality control of main procedures performed by the laboratory.
For the accurate etiological diagnosis of infection, several conditions should be fulfilled: first, the clinician should put the right indication for the diagnostics; furthermore, the right sample should be taken; then, all data needed for the laboratory should be put on the request (name of the patient and the physician, location of the patient, date and time of specimen collection, working diagnosis or differential diagnosis, underlying patient conditions, and antimicrobial chemotherapy if already instituted). Specimens sent to the microbiology laboratory have to be taken on the right time (depending on the pathogenesis of the infection), from appropriate sites using proper techniques, in a quantity that will ensure good results in the laboratory. Transport conditions from the patient to the laboratory are to be carefully maintained. Microbiology laboratory staff can assist in ensuring good specimens by educating clinical staff. Rapid and accurate diagnosis and sensitivity testing are of outmost importance for direct patient care. In the laboratory methodology, it is necessary to provide rapid tests (like pneumococcal urine antigen in the case of community acquired pneumonia, or rotavirus, latex agglutination for detection of rotavirus in feces etc.). The Microbiology laboratory also should be able to examine blood, cerebrospinal fluid (CSF), urine, stool, wound exudate or swabs, respiratory secretions, and perform basic serological tests (HIV, HBV, HCV, influenza). The Microbiology lab should be able to identify at least the following bacteria and fungi: Staphylococcus aureus, Escherichia coli, Group A streptococci, Group B streptococci, Enterococci, Streptococcus pneumoniae, Haemophilus influenzae, Neisseria meningitidis and Neiserria gonorrhoeae, Salmonella, Shigella, Campylobacter jejuni/coli, Clostridium difficile, Pseudomonas aeruginosa, Klebsiella pneumoniae, other Enterobacteria, Candida albicans, aspergilli (and other, depending on the local epidemiological situation); also, it should be able to diagnose specific viral infections (e.g., some of viruses causing diarrheal diseases), but mostly using serological methods (HIV, HBV, HCV, influenza, or other viruses, depending on the local epidemiological situation).

Methods used in the diagnosis of infections are:

1. Classical methods, such as
   - Direct smear
   - Culture
   - Antigen detection
   - Serological tests

And

2. Molecular methods (not very often used in routine work)
   - Hybridization
   - Amplification
   - Real-time amplification

For purposes of this course, you are not required to be familiar with the specifics of these methods. Those details will be provided if you take the PHC 6562 "Microbiology for Healthcare Workers" course.
Microbiology's Role in HAI Prevention

1. Rapid communication
2. Accurate speciation & typing of isolated pathogens
3. Participation in outbreak management
4. Participation in HAI surveillance
5. Participation in resistance surveillance
6. Education of HAI prevention team & other HCWs
7. Microbiologist-member of Infection Control Committee/Team & Antibiotic Committee

For the second main function of the Microbiology Laboratory, the role in HAI prevention, there are numerous responsibilities. On this slide, 7 responsibilities are listed. They are:

1. Rapid communication
2. Accurate speciation & typing of isolated pathogens
3. Participation in outbreak management
4. Participation in HAI surveillance
5. Participation in resistance surveillance
6. Education of HAI prevention team & other HCWs
7. Microbiologist-member of Infection Control Committee/Team & Antibiotic Committee

We will go through each one in more detail.

Rapid Communication

- IPs should communicate at least daily with Micro. Lab
- If not possible, Micro. Lab should communicate every time there is a new important isolation pathogen
- Panic list should be developed, reviewed regularly & revised as necessary
- Rapid communication crucial

The first responsibility is rapid communication. Infection Preventionists (IPs) should ideally start their days in the microbiology laboratory, personally or virtually. This would be the best and the most rapid communication of everyday infectious problems IPs can encounter in the healthcare facility. If this is not possible, then laboratory workers should communicate by phone or personally with the IP for every new important isolated pathogen in patients. A panic list with what events warrant contacting the IP team, needs to be developed, reviewed regularly by the Micro. Lab and IP team, and revised as necessary. This rapid communication is crucial and is the base of any good collaboration between microbiology laboratory and infection control.

Accurate Speciation & Typing of Isolated Pathogens

- Identify bacterial strains to species level
- Often enough for pathogenic bacteria (e.g., S. enteritidis)
- If isolated bacteria opportunistic pathogens (e.g., S. aureus, E. cloacae), may need to type isolates
- Example

The second responsibility is accurate speciation and typing of isolated pathogens. To be useful for epidemiological studies of HAI, isolated bacterial strains should be identified to the species level. Many times this is enough for definite epidemiological analysis of small clusters or even outbreaks of HAI if pathogenic bacteria are involved (e.g. Salmonella Enteritidis food poisoning outbreak originated from hospital kitchen). But, if the isolated bacteria are only opportunistic pathogens (e.g. S. aureus, E. coli, Enterobacter cloacae, Enterococci etc.) it is necessary to type those isolates to be sure that the cluster or outbreak patients are connected. To type means to determine characteristics which differ between different strains of the same bacterial species. Namely, the individual bacteria inside the same species could differ in their genome as much as 30%, and in the individual bacterial clone (clone= offsprings of the common ancestor) these differences are very small or even non-existent. Bacterial typing determines if two or more strains are really related and if they differ from strains that are not epidemiologically connected. If two (or more) strains are unrelated, the patients do not belong to the same outbreak, it is very simple to interpret that pattern. But, if two (or more) strains are related after strain typing was performed, it is very difficult to say that the patients are involved in an outbreak without sound epidemiological analysis.
Third is participation in outbreak management. The early isolation of a new or unusual microorganism enables the IP to take appropriate measures to stop it from spreading at the very beginning. Any new isolates should be reported immediately to the wards and the IP. Laboratory staff may also report clustering of infections (two related isolates in different patients in the same time frame), which then enables the IP to go and check these cases. In an outbreak suspected to be caused by one and the same causative agent it is very helpful (and sometimes even necessary) for the agent to be isolated, identified to the species level and also typed.

Surveillance of HAI is an important task of a well-organized infection control program. With either “alert” or multi-drug resistant (MDR) organisms surveillance, the role of the microbiology laboratory is crucial. Some of the most important ‘alert’ microorganisms are:

- Methicillin-resistant Staphylococcus aureus (MRSA)
- Vancomycin-intermediate S. aureus (VISA)
- Vancomycin-resistant Enterococci (VRE)
- MDR Pseudomonas aeruginosa
- MDR Acinetobacter baumannii
- MDR Mycobacterium tuberculosis
- Extended-spectrum Beta-lactamase (ESBL) enterobacteria
- Clostridium difficile

The microbiology laboratory should produce routine reports to allow the IP to make graphs for specific pathogens, wards, and groups of patients, or better yet, produce these reports themselves. A ‘baseline incidence’ can be then established and any new isolate incidence can be compared with this baseline. If such graphs are in the form of time series, they will enable the IP to discover the beginning of an outbreak earlier than it would be possible clinically. Periodic reports also demonstrate trends of specific pathogens and can be very useful in planning preventive measures. The Microbiology Laboratory also participates in routine process surveillance, monitoring sterilization and dialysis fluid. Sometimes it may be useful to routinely monitor some other processes, like infant formula and instrument disinfection. More on this in a few minutes.

The surveillance of bacterial resistance to antimicrobial agents is a very important task of the microbiological laboratory. It is prudent to have an antibiotic management team in healthcare facilities, to make policies for antibiotic use with the ultimate goal to decrease this resistance. Resistance reports are usually periodical (yearly reports) and it is very useful to have resistance surveillance organized on regional or country or even international levels, to cope with the resistance development on a broader scale (for example, European Antimicrobial Resistance Surveillance System).
The Microbiology staff provides invaluable education. First, they act as an educator for infection control personnel, on topics such as: characteristics of microorganisms that are important for epidemiology of infections, about normal flora, the difference between contamination, colonization and infection with specific organisms, and interpretation of microbiological reports and charts. The Microbiology laboratory staff also serve as educators to other healthcare workers, regarding specimen collection and transport as well as interpretation of microbiology findings. They can also provide education on basic clinical microbiology for medical and nursing students.

Microbiology staff have the specialty knowledge that makes them indispensable on several healthcare committees/teams. First, there should be a representative from the Microbiology Lab on the Infection Prevention Committee if the healthcare facility has one. Next, there should be a representative from this lab in the core infection prevention team. Finally, their representation is crucial on antibiotic committees participating in efforts to decrease transmission of antibiotic resistant organisms. Up to this point, the reference for these 7 responsibilities is: The role of the microbiology laboratory in healthcare-associated infection prevention. Smilja Kalenic’ & Ana Budimir. International Journal of Infection Control, 2009, available at: www.ijic.info/article/download/3667/3202. The link is provided on this slide.

This is an excerpt from Required Reading #1. It outlines the necessary functions that the microbiology laboratory must perform to support the infection prevention and control program. Note that most of these are contained in the 7 responsibilities we have just outlined. We will next discuss those functions that were not previously identified.

The Pathology and Laboratory Medicine departments should have a written, department specific infection control and prevention plan for preventing the transmission of infections that is consistent with the plan for the entire organization. The departmental plan should delineate activities for patients, workers, and trainees that are required to reduce the transmission of infections, facilitate hand hygiene, address screening for pathogen exposure, assess immunity to such potential exposures, minimize the risk from handling medical devices, outline the management of infected personnel who may be a risk to others, and describe the availability and use of personal protective equipment.
<table>
<thead>
<tr>
<th>Slide 16</th>
<th>Qualified and trained personnel are required to run the Microbiology Laboratory as well as the department's infection control program. There are numerous sources for education. The extent of experience and/or training needed to support the laboratory's infection control plan will be dictated by the size of the healthcare organization and the complexity of the patients being cared for within the system. For more information on the educational and practice requirements of microbiology personnel, you can visit the website of the American Society for Microbiology (ASM).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slide 17</td>
<td>The clinical Micro. Lab has many requirements for effectively transmitting the information it generates and collects. A key element to ensure that the methods used to detect potential infection with healthcare-associated pathogens are highly accurate. We have already discussed the need for daily or at least regular communication between the lab and infection preventionists. In addition, the United States communicable disease surveillance system depends upon reporting by clinical and public health laboratories. The clinical microbiology laboratory must work closely with the infection preventionists to ensure that the reporting system is well organized, that all required reports are efficiently transmitted, and avoiding duplication that can waste personnel resources. Use of electronic medical records can greatly enhance communication and reporting when well-coordinated between the laboratory, infection preventionists, clinicians and others who need to know microbiological information in a healthcare facility.</td>
</tr>
<tr>
<td>Slide 18</td>
<td>The Microbiology Laboratory performs numerous activities. We will discuss 3 of those activities with infection prevention implications. The first is antimicrobial susceptibility testing. The second is generation of antibiograms. The third is environmental testing, both routine and special.</td>
</tr>
<tr>
<td>Slide 19</td>
<td>Antimicrobial therapy seeks to suppress (bacteriostatic) or kill (bactericidal) microorganisms by exploiting biochemical reactions unique to the pathogenic microbe. Ideally, this should be accomplished using the simplest agent with minimal toxicity to the patient. Originally, the purpose of susceptibility testing, sometimes referred to as sensitivity testing, was to determine whether the organism isolated was able to resist the effect of the therapeutic agent chosen for treatment. However, as processes have evolved, there are AST methods available that directly measure the activity of one or more antimicrobial agents against a bacterial isolate, directly detect the presence of a specific resistance mechanism in a bacterial isolate, and measure complex antimicrobial-organism interactions. The type and extent of the AST conducted depends on the organism isolated, the source of the culture (body site), available antimicrobial agents,</td>
</tr>
</tbody>
</table>
and typical susceptibility patterns. Several methods may be used for susceptibility testing.

---

<table>
<thead>
<tr>
<th>Slide 20</th>
<th>On this slide is a diagram showing a culture testing several antibiotics against a specific organism. The white areas indicate a zone of inhibition, where there is no growth of the organism. The colored area indicates growth of the organism.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Slide 21</th>
<th>On this slide, the top plate shows that for organisms plated together, none of the 5 antimicrobial agents tested are effective. In the bottom two plates, for the organisms plated separately, they are susceptible to 2 antimicrobial agents each.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Slide 22</th>
<th>On this slide is a sample AST report. It contained the percentage of susceptibility between 0 and 100 on the x-axis and the antibiotic tested on the y-axis. There are 3 shades of susceptibility: susceptible, intermediate and resistant, and this report tested the gram-negative organism <em>Klebsiella pneumoniae</em>. The clinician uses ATS to determine how to treat a patient’s infection. The IP would use such a report to determine if this patient had a resistant organism requiring additional isolation precautions.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Slide 23</th>
<th>On this slide is another example of an AST report. This report shows the susceptibility of 11 different methicillin-resistant <em>Staphylococcus aureus</em> isolates to 6 different antimicrobial agents.</th>
</tr>
</thead>
</table>
Most laboratories generate an antibiogram - a report that contains a summary of common organisms recovered and their resistance patterns to commonly prescribed antibiotics. Each healthcare setting is often unique for the patient population served in that geographic area. Some reports may include differentiation between isolates recovered from inpatient and outpatient specimens. This periodic report assists the physician in ordering prompt and appropriate antibiotics based on the most likely bacteria for the site while awaiting final culture and susceptibility results. An antibiogram is the result of a laboratory testing for the sensitivity of an isolated bacterial strain to different antibiotics. The antimicrobial susceptibility data generated from testing individual patients' microbial isolates can be helpful if cumulative data from such tests are assembled and appropriately reported at regular intervals. For the cumulative reports to be useful and comparable with those of previous years or other institutions, data must be obtained and presented in a clear and consistent manner. The primary function of the cumulative antimicrobial susceptibility test data reports is to aid clinicians in the selection of the most appropriate agents for initial empirical antimicrobial therapy. Empiric antimicrobial therapy is antibiotic therapy commenced before the identification of the causative microorganism is available. Typically, full identification and susceptibility testing of bacteria from clinical specimens is not available for 48-72 hours after collection of the specimen from the patient. Thus, information about microorganisms and their susceptibility to specific antibiotics in the form of an antibiogram can aid the clinician in the selection of empiric therapy.

On this slide is a table depicting the required and optional components of an antibiogram. The required basic elements are: antibiotics tested, organisms tested, the number of isolates for each organism, the percent susceptible data for each drug-pathogen interaction, specimens sites (e.g., urine, sputum, etc.), and specific unit notations (e.g., intensive care, outpatient clinic, etc.). Optional components can be divided into 3 categories: 1) antibiotic information (e.g., dosing, cost), 2) policy issues (e.g., restricted or protocol drugs), and 3) additional information (e.g., body surface areas, footnote).

On this slide is a sample antibiogram. Please review it to become familiar with its components.
On this slide is another sample antibiogram. Please review all components including the footnotes.

The IP may be asked about performing cultures from environmental sources. **Routine** microbiologic sampling for quality assurance purposes should be limited to: (1) biologic monitoring of sterilization processes; (2) monthly cultures and endotoxin testing of water and dialysate in hemodialysis units; and (3) short-term evaluation of the impact of infection prevention measures or changes in infection prevention protocols. Other **special** environmental testing should NOT be done without purpose or direction, for example, as part of an outbreak investigation. It is imperative in these instances that the Micro. Lab. be consulted before any unit or department submits any environmental cultures, for several reasons. First, it must be determined that the lab has the staffing to perform the number of cultures necessary. Next, the unit or department needs to be informed exactly how to collect, store and transport the specimens. Third, the micro lab in conjunction with the infection control team must see the results and interpret them before releasing to the units or departments. Examples of when special environmental testing may be indicated are when epidemiological investigation suggests that a source or reservoir of microorganisms may exist. Such testing may involve personnel, medical devices, air, water, food, and/or surfaces. The type of sampling depends on the causative organism, type of infection, and potential sources/reservoirs. Quantitative test methods (which determine the amount of an organism present) should be used rather than qualitative methods (which only determine if an organism is present).

It is important for the infection preventionist (IP) to establish a good working relationship with the director of microbiology or the chief of the department so that they can feel comfortable enough to pursue any future matter. It would also be wise for any new IP personnel to spend a week or more in the department, learning its dynamic in order to better understand the workflow and the capacity of the lab. I spent 2 weeks in the Micro. Lab as a brand new IP and can attest to its value. Historically, in the 1970s, when infection control first was recognized as a valuable specialty and up to today, individuals with nursing backgrounds are probably the largest professional cohort that become IPs. Medical technologists, especially those from microbiology, are the second largest group. Those with epidemiology backgrounds or a master’s degree in public health are probably the third-largest group. The IP may be able to recruit laboratory personnel to become future IPs. Potential collaborative building exercises would be to invite them to local APIC meetings, include them in various task forces that promote methods to reduce the risk of
infectious diseases at your facility and in the community, and to promote patient and worker safety related to emerging pathogens and healthcare associated infections.

Slide 30

Closing Comments

• Microbiology lab essential component of infection control program
• Lab personnel have ↑ technologies to support IC program
• Both need to communicate shared goals
• Reduce risk of HAI & frequency of resistant organisms

On this slide is an excerpt from an article about the importance of the microbiology in an infection control program. “The clinical microbiology laboratory is an essential component of an effective infection control program. Laboratory personnel have a broad range of technologies, from traditional methods of detecting and identifying organisms to modern molecular typing methods, that they can use to support and enhance the efforts of the infection control staff. If the infection control team applies these technologies appropriately, it can prevent problems and solve nosocomial mysteries efficiently. In this era of cost-containment, staff members in the laboratory and in the infection control program must work hard to communicate their unique and shared goals, needs, and problems. If the laboratory and infection control personnel cooperate and collaborate rather than compete, both programs will be successful and the patients and the hospital will benefit because the risk of nosocomial infections and the frequency of resistant organisms will be reduced.” (Source: The clinical microbiology laboratory and infection control: emerging pathogens, antimicrobial resistance, and new technology. Pfaffer MA, Herwaldt LA. Clin Infect Dis. 1997 Oct; 25(4): 858-70, available at: http://www.ncbi.nlm.nih.gov/pubmed/9356802, the link provided in the transcript and on the slide.

This concludes the lecture for Unit 10.