Analysis of Microbial Resistance and Prescription Preferences using Antibiograms

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Abstract

Introduction: Hospital antibiogram is a periodic summary of antimicrobial susceptibilities of local bacterial isolates submitted to the hospital’s clinical microbiology laboratory. It not only aids clinicians to select the most appropriate empiric therapy, but also in monitoring resistance trends within an institution, thereby optimizing treatment.

Aims: To analyze the susceptibility trends of microbes by using antibiograms; assess the modification in prescribing empirical therapy and examine application of the susceptibility report in clinical practice.

Settings and design: A retrospective study of culture sensitivity reports and indoor prescriptions from departments of Medicine, Pulmonary medicine, Surgery, Orthopaedics, Obstetrics and Gynaecology and Intensive Care Unit.

Methods and material: Culture sensitivity reports of samples collected from these specialties were analyzed for the susceptibility pattern of antibiotics. In addition, prescriptions were analysed for the prescribing patterns for antimicrobials.

Statistical analysis used: The data was tabulated using Microsoft Office Excel 2010 and were later compiled to make an antibiogram. Chi-square values were calculated using online software Graphpad Quickcalcs.

Results: After analysing the data it was found that the most common infecting organisms were Pseudomonas aeruginosa, Escherichia coli and Staphylococcus aureus susceptible to amikacin, piperacillin/tazobactam and linezolid. However the prescriptions analysed revealed that the commonly prescribed drugs were ceftriaxone and amoxyccillin/clavulanic acid.

Conclusions: Antibiogram is useful in predicting and monitoring the trends of antimicrobial resistance. The survey revealed a clear mismatch between the sensitivity reports and the prescribing trends which can lead to evolution of multi-drug resistant organisms.

Keywords: Drug and therapeutic committee; Empiric therapy; Susceptibility pattern

Introduction

Discovery of antibiotics was one of the most celebrated achievements of modern medicine in 20th century. With the advent of ‘Golden era of antibiotics’, human life-expectancy has significantly increased by cure of previously fatal infections. However, almost half a century after introduction of these ‘Wonder drugs’, the emergence of stubborn, resistant microbes is the biggest threat we are facing right now. Antimicrobial resistance is defined as decrease in susceptibility of a microorganism to an antimicrobial agent to which it was previously sensitive. As a result, standard treatments become ineffective and infections persist and may transmit to others [1]. It’s a matter of global concern since it possesses a significant clinical and financial burden. It is estimated that US$ 30 billion is spent on the cumulative effects of antimicrobial resistance each year including multiple drug regimens, extra hospital days, additional medical care and lost productivity. Studies show that mortality, duration of hospital stay and healthcare costs for patients with methicillin-resistant Staphylococcus aureus (MRSA) infections was higher as compared to methicillin sensitive S.aureus infections [2].

Methicillin-resistant Staphylococcus aureus (MRSA) was first reported in 1961 and became endemic in many hospitals worldwide by 1980s. With the widespread emergence of MRSA, glycopeptide antibiotics such as vancomycin have been more frequently used in the clinical practice. This has led to sporadic cases of glycopeptides resistance. In the 90s, fluoroquinolone resistance in E. coli became prominent. The situation is still very volatile as infections caused by antimicrobial-resistant pathogen continue to haunt the clinicians. Furthermore, several highly resistant gram-negative bacteria- namely Acinetobacter species, multidrug-resistant (MDR) P. aeruginosa, and carbapenem-resistant Klebsiella species and Escherichia coli, are emerging as significant pathogens in both the United States and other parts of the world. Our therapeutic options for these pan-antibiotic
resistant microorganisms are so extremely limited that clinicians are forced to re-introduce older, previously discarded drugs, such as colistin, that are associated with significant toxicity and for which there is a lack of robust data to guide selection of dosage regimen or duration of therapy [3]. To emphasize on their rising danger and the matter of fact that these pathogens conveniently ‘escape’ the effects of anti-bacterial agents, they were collectively termed ESKAPE group of organisms; where ESKAPE stands for Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumanii, Pseudomonas aeruginosa, and Enterobacter species [4]. Recently, Clostridium difficile too has been added to the list. Lately Indian subcontinent has been in the spotlight for Superbug containing patients in their ICU increased from 48.0% before the creation of anti-bacterial agents, they were collectively termed ESKAPE group of antibiotic therapy chosen does not cover the pathogens causing the infections and of those, 80% were unnecessary according to CDC guidelines [5]. There may be many contributory factors to it like demands from patients, peer pressure, fancy perks from pharmaceutical industries leading to overuse of a particular type of antibiotic, diagnostic uncertainty, pressure to keep hospital-stay short and last but not least, physicians’ lack of knowledge about the local susceptibility patterns which has been cited as one of the top causes. This is where cumulative antibiogram comes to the rescue.

One of the most important reasons for development of antimicrobial resistance is indiscriminate use of antibiotics. For example, antibiotics were prescribed in 68% cases of acute respiratory tract infections and of those, 80% were unnecessary according to CDC guidelines [5]. There may be many contributory factors to it like demands from patients, peer pressure, fancy perks from pharmaceutical industries leading to overuse of a particular type of antibiotic, diagnostic uncertainty, pressure to keep hospital-stay short and last but not least, physicians’ lack of knowledge about the local susceptibility patterns which has been cited as one of the top causes. This is where cumulative antibiogram comes to the rescue.

Cumulative Antibiogram is defined as report generated by analysis of isolates from particular institution in a defined period of time that reflects percentage of 1st isolate per patient of given specie that is susceptible to each of antimicrobial agents routinely tested [6]. It is a pre-requisite for any antibiotic policy, to steer the physicians to select the most appropriate empiric antibiotic therapy. For instance, it is known that for patients in ICUs, mortality rises if the empiric antibiotic therapy chosen does not cover the pathogens causing the infection. Kollef et al. showed that infection-related mortality was 17.7% in those patients who received appropriate empiric therapy and 42% in those who received inapt empiric antibiotic therapy [7]. The most common reason for the unsuitability of the chosen empiric antibiotic therapy was the resistance of bacteria to the antibiotic selected. In an effort to improve the adequacy of antibiotic selection, Ibrahim et al. reviewed the antibiogram for their ICU and created a clinical guideline for antibiotic selection in that unit. The adequacy of empiric antibiotic selection for ventilator-associated pneumonia for patients in their ICU increased from 48.0% before the creation of antibiotic guidelines to 94.2% with the use of their guidelines [8]. Antibiograms are regarded as cost-effective and convenient method of assessment of local susceptibility rates and monitor resistance trends overtime in institutions.

The compilation and presentation of an antibiogram is generally initiated by the clinical microbiology laboratory with collaboration from clinicians, pharmacologists and infection control personnel. This document demonstrates recent, precise, and clinically useful data in an organized manner. The development of sophisticated computer programs like WHO-NET software and improvements in laboratory information systems assist in this process.

The objective of our study was to analyze antimicrobial susceptibility trends by using Antibiograms and compare the susceptibility rates with the antibiotic prescribing patterns across the institution. This analysis was then used to orient the clinicians in attempt to rationalize their antibiotic prescribing habits and contain the emergence and spread of resistance.

Materials and Methods

Study location

The present study was conducted in Guru Nanak Dev Hospital, Amritsar; adjoined to Government Medical College, Amritsar. It is a 1000 bedded tertiary care health institution. Departments included were Medicine, Pulmonary medicine, Surgery, Orthopedics, and Obstetrics and Gynecology.

Study period


Prescription analysis: From 1st May, 2013 to 31st July, 2013

Study population

All the patients admitted to aforementioned departments during the period of the study were included.

Inclusion criteria

1. Susceptibility reports of only Indoor patients were taken into consideration.
2. To prepare the antibiogram 1st diagnostic isolate of given specie per patient per analysis period was included, irrespective of body site, antimicrobial susceptibility profile or other phenotypic characters [9].
3. Blood, urine and pus cultures were included.
4. Prescriptions of adult patients above 18 years with antibiotic medications were collected for analysis.

Exclusion criteria

1. Antibiotic sensitivity test reports from laboratories other than Microbiology department of our institute were excluded
2. While preparing the antibiogram, the following isolates were excluded:
   a. Duplicate bacterial isolates [9]
   b. Surveillance culture and screening isolates [9]
   c. Isolates of the colonizers [9]
   d. Strains which show intermediate susceptibility
   e. CSF isolates
3. Patients already on antibiotics were also excluded
4. The approval of the ethics committee of the institution was obtained
Data collection and analysis

1. To prepare antibiogram: Culture sensitivity reports for the aforementioned departments (Table 1) were collected and since least no of culture sensitivity reports were from Pulmonary medicine (423) therefore, we evaluated 400 culture sensitivity reports from each department. Antibiograms were prepared by plotting the number of isolates of a particular micro-organism against the antibiotic to which they were found susceptible.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Department</th>
<th>No. of culture sensitivity reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medicine</td>
<td>528</td>
</tr>
<tr>
<td>2</td>
<td>Pulmonary medicine</td>
<td>423</td>
</tr>
<tr>
<td>3</td>
<td>Surgery</td>
<td>451</td>
</tr>
<tr>
<td>4</td>
<td>Orthopedics</td>
<td>469</td>
</tr>
<tr>
<td>5</td>
<td>Obstetrics and Gynecology</td>
<td>448</td>
</tr>
</tbody>
</table>

Table 1: Culture sensitivity reports for the aforementioned departments.

For prescription analysis

a) Prescriptions for antibiotic empiric therapy from each of the aforementioned departments were collected during the study duration specified previously and all the prescriptions satisfying the inclusion criteria were included in the study (Table 2). Prescriptions were analyzed for empirical antibiotic therapy received, which was compared with the sensitivity pattern in the antibiogram.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Department</th>
<th>No. of prescriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medicine</td>
<td>346</td>
</tr>
<tr>
<td>2</td>
<td>Pulmonary medicine</td>
<td>286</td>
</tr>
<tr>
<td>3</td>
<td>Surgery</td>
<td>325</td>
</tr>
<tr>
<td>4</td>
<td>Orthopedics</td>
<td>316</td>
</tr>
<tr>
<td>5</td>
<td>Obstetrics and Gynecology</td>
<td>314</td>
</tr>
</tbody>
</table>

Table 2: Prescriptions for antibiotic empiric therapy from each of the aforementioned departments.

b) To construct the antibiograms and prepare the final results, Microsoft Office Excel 2010 software was used. Statistical analysis of antibiotic prescription against organism susceptibility was done by Chi-square test (χ2). Chi-square values were calculated using online software Graphpad Quickcalcs.

Results

Data from 2000 Culture sensitivity reports was piled up to prepare antibiogram and 1587 Prescriptions were evaluated for prescribed drug against its organism susceptibility for particular antibiotic in percentage. Most common infecting organism isolated in samples from various departments was as given in Table 3.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Department</th>
<th>Most common organism</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medicine</td>
<td>E. coli</td>
</tr>
<tr>
<td>2</td>
<td>Pulmonary medicine</td>
<td>P. aeruginosa</td>
</tr>
<tr>
<td>3</td>
<td>Surgery</td>
<td>S. aureus</td>
</tr>
<tr>
<td>4</td>
<td>Orthopedics</td>
<td>S. aureus</td>
</tr>
<tr>
<td>5</td>
<td>Obstetrics and Gynecology</td>
<td>S. aureus</td>
</tr>
</tbody>
</table>

Table 3: Most common infecting organism isolated in samples from various departments.

Discussion

Antibiogram is a versatile document which, besides exhibiting the antibiotic susceptibility pattern across the institution, presents a clear picture of the most common disease-causing organisms in various units of the hospital. Nosocomial infections are a major public health concern these days and a cause of considerable mortality and morbidity for hospitalized patients. They occur among 7-12% of the hospitalized patients globally, with more than 1.4 million people suffering from the infectious complications acquired in the hospital [10].

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Our study deals with the analysis of culture-sensitivity reports of only indoor patients, thus, the chances of coming across nosocomial or Hospital Acquired Infections (HAI) were high. In our study, the antibiograms of various departments indicated that most common pathogens isolated were gram negative bacilli (Medicine 72%, Pulmonary medicine 76%, Surgery 63%, Orthopedics 68% and Obstetrics and Gynecology 48%). Among the array of gram negative organisms, the Enterobacteriaceae family was the most frequently identified group overall. Recent data from the U.S. National Healthcare Safety Network indicate that gram negative bacteria are accountable...
for more than 30% of hospital-acquired infections [11]. Among the HAI s caused by Gram negative bacilli, urinary tract infections were most prevalent. Klevens et al. have reported in their study that UTI accounts for more than 30% of infections reported by acute care hospitals [12]. Most of it has been found to be related with catheterization, generally known as Catheter-associated Urinary tract infection (CAUTI). Urinary catheters are used routinely in the wards of our hospital, usually for frequent and accurate monitoring of urinary output. And this can lead to increase in number of isolates of Gram negative pathogens.

In Pulmonary medicine ward, the most common individual organism was Pseudomonas aeruginosa (35%). This finding is in agreement with reports from USA that suggest that P. aeruginosa is the most frequent bacterium isolated from the respiratory tract (31.6%) [13]. This can be attributed to patients of Community and Hospital-acquired pneumonia admitted in that ward. Hospital-acquired pneumonia by P. aeruginosa may also be iatrogenic. Being an extremely adaptable organism it can survive and multiply even with minimal nutrients, if moisture is available. Thus, equipment such as respirator and bronchoscopes can be frequently contaminated.

On analysis of culture-sensitivity reports from Surgical units i.e. Surgery and Orthopedics, it was observed that Staphylococcus aureus (27% and 29%, respectively) was most commonly encountered organism in our hospital, usually for frequent and accurate monitoring of empiric antibiotic therapy with the antibiograms, we observed that in Obstetrics wards (45%) and most commonly isolated bacteria from infection (CAUTI). Urinary catheters are used routinely in the wards of our hospital, usually for frequent and accurate monitoring of urinary output. And this can lead to increase in number of isolates of Gram negative pathogens.

Therefore to summarize, there was gross disparity between sensitivity pattern and the antibiotic prescribing trend in various wards. Irrational use of antimicrobials is the biggest contributing factor to the growing peril of resistance especially in low-income countries [17]. In our study, we observed a clear mismatch between culture-sensitivity pattern and antibiotic prescribing trend. Linezolid is a synthetic antimicrobial agent of the oxazolidinone class [18]. In this study, Linezolid illustrated an organism susceptibility rate of 23%, 27% and 38% in Surgery, Orthopedics and Obstetrics-Gynecology, respectively. However in all the three departments, it was not prescribed routinely. The most probable rationale behind this observation can be the fact that Linezolid is considered to be a ‘Reserve Drug’ [21], set aside as an alternative agent for treatment of infections caused by multi-drug resistant strains like vancomycin-resistant E. faecium, nosocomial pneumonia caused by methicillin-resistant strains of S. aureus, complicated skin and skin-structure infections caused by MRSA [19].

In the present study, antibiotics were segregated on the basis of different units where patients were admitted. Unit-specific antibiograms gives a superior picture of the organism susceptibility spectrum and thereby, the resistance trends since it is known that patterns of resistance to antibiotic vary widely between as well as within healthcare institutions. In the same way, unit-wise antibiogram prepared in our study clearly depicted the variations in isolated microorganisms, susceptibility trend and the antibiotic prescribing practices, as mentioned above. It also illustrated the odd resistance patterns in specific areas of the hospital. Institution-wide antibiograms may conceal important differences in susceptibility data across units within the institution. These differences may be significant, not only for selecting most effective empirical antimicrobial therapy for a patient in that unit but also for monitoring the emerging patterns of antimicrobial resistance specific to certain units within the institution [20].

Limitations of the Study and Challenges of Antibiogram

The present study had the following deficiencies:-

1. The antibiogram susceptibilities in our study may not forecast the best empirical drug combination because of unpredictable cross resistance. Cross-resistance should be taken into consideration to choose the initial combination regimens for serious gram negative infections, especially, P. aeruginosa [21].

2. Many culture sensitivity tests are frequently outsourced to the laboratories, other than our Institution’s own Microbiology department. Hence, it is difficult to generalize the inferences of our findings for all the patients admitted.
3. Intensive care unit (ICU) was not included in our study since very few specimens were sent for culture sensitivity tests to the Microbiology department. It is because ICU is not an independent unit in our institution. The requests for culture sensitivity tests are sent by the respective departments under which the patient is admitted.

4. All the data was collected and analyzed manually. WHO NET software was not used.

Conclusion

The present study reveals a clear mismatch between susceptibility reports and prescribing trends which can give rise to antibiotic resistance. To rectify these discrepancies in prescribing pattern, Antibiotic policy and institutional Drug and Therapeutic Committee is one of the mandatory requirements for accreditation, and making an antibiogram is the first step before framing the antibiotic policy. With a collaboration between departments of pharmacology, microbiology and the clinicians, it will not only review the antibiograms but will also regulate the antibiotic prescribing thereby enhancing its efficacy and promoting its rational use.

References