Scientific Research Publishing

Advances in Microbiology, 2024, 14, 25-30
https://www.scirp.org/journal/aim
ISSN Online: 2165-3410
ISSN Print: 2165-3402

Characteristics of β-Lactamase Synthesis in *E. coli* and *K. pneumanie* Strains in Nosocomial Infections

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How to cite this paper: Atakishizadeh, S.A., Atakishizadeh, S.A. and Davudov, M.M. (2024) Characteristics of β-Lactamase Synthesis in *E. coli* and *K. pneumanie* Strains in Nosocomial Infections. *Advances in Microbiology*, **14**, 25-30.
https://doi.org/10.4236/aim.2024.141003

Received: November 1, 2023
Accepted: January 12, 2024
Published: January 15, 2024

Abstract

Background: Recently micro-organisms that synthesize extended-spectrum β-lactamase (ESBLs) were increased. The peculiarities of ESBL synthesis of Escherichia coli and *Klebsiella pneumoniae* strains that cause nosocomial urinary tract infections, surgical site infections and pneumonia in surgical clinic were studied. ESBL synthesis were observed 38.9% of *E. coli* strains obtained from urine, 92.3% of strains obtained from surgical site infections, and 50% of strains obtained from sputum. ESBL synthesis were observed 37.5% of *K. pneumoniae* strains obtained from urine, 85.7% of strains obtained from surgical site infections, and 60% of strains obtained from sputum. Different levels of ESBL synthesize of *E. coli* and *K. pneumoniae* strains isolated from different pattern is discussed. Conclusion. ESBL synthesis is common in *E. coli* and *K. pneumoniae* strains, which cause nosocomial infections. The frequency of occurrence of ESBL s synthesis among of these strains depends on clinical forms of nosocomial infections.

Keywords

Nosocomial Infectious Agents, β-Lactamase Synthesis, *E. coli* and *K. pneumoniae*

1. Introduction

The production of various enzymes that break down antibiotics in microorganisms is one of the mechanisms that play a key role in the formation of resistance to antimicrobial drugs. One such enzyme is beta-lactamase, which cleaves the beta-lactam ring in beta-lactam antibiotics and inactivates them. The production of these enzymes in microorganisms is usually encoded by genes located in

plasmids. Since these genes can be transferred to other bacteria mainly by the conjugation mechanism, beta-lactamase-related resistance spreads with high frequency throughout the microbial population. It should be noted that resistance to beta-lactamases is widespread among both gram-negative and gram-positive bacteria.

Today, microorganisms that synthesize extended-spectrum beta-lactamase (ESBLs) are increasing [1] [2]. ESBLs can also break down antibiotics that are resistant to conventional beta-lactamases, providing resistance to them. Thus, ESBL-synthesizing microorganisms also have resistance to antibiotics of third and fourth generation cephalosporins, which are known to be resistant to beta-lactamases.

The purpose of the research was to study the characteristics of ESBL synthesis in Escherichia coli and *Klebsiella pneumoniae* strains, which are the etiological factor of pneumonia, and nosocomial urinary tract and surgical site infections encountered in AMU Teaching Surgery Clinic in 2020-2022.

2. Materials and Methods of Research

After inoculation of appropriate examination materials (urine, pus, sputum, etc.) obtained from examined patients on various nutrient media—Mueller Hinton agar, blood agar, EMB agar, and incubation for two days, the obtained cultures were identified by generally accepted methods (taking into account morphological, cultural, biochemical, etc. signs). Antibiotic susceptibilities were determined by disc-diffusion method according to the recommendations of EUCAST (European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Version 4.0, valid from 2014-01-01) [3].

ESBL synthesis in *E. coli* and *K. pneumoniae* strains was determined by phenotypic test—using two discs [4]. For this, an Amoxycillin+Clavulanic acid disc was placed directly next to the Cefotaxime disk placed on the surface of the solid nutrient medium inoculated with the appropriate bacterial strain. The result was evaluated after one day of incubation. If the bacterial strain synthesizes ESBLs, the sterile zone around the Cefotaxime disc extends towards the Amoxycillin+Clavulanic acid disc.

To compare the obtained results, the nonparametric *Wilcoxon-Mann-Whitney* test was used, in addition, Pearson's correlation coefficient X^2-meyarı) and Student's coefficient (p) were applied [5].

3. Results of the Research

E. coli was found in 18 (40.9%) of 44 patients with nosocomial urinary tract infection, 13 (32.5%) of 40 patients with surgical site infection and 4 (9.8%) of 41 patients with pneumonia. *K. pneumoniae* was found in 18 (40.9%) of 44 patients with nosocomial urinary tract infection, 7 (17.5%) of 40 patients with surgical site infection and 5 (12.2%) of 41 patients with pneumonia.

When analyzing the characteristics of ESBL synthesis in *E. coli* strains, which

are the causative agents of nosocomial infections, ESBL synthesis was determined in 7 (38.9%) of the *E. coli* strains obtained from urine, in the majority (in 12 out of 13 strains - 92.3%, $X^2 = 30.89$, $p < 0.05$) of *E. coli* strains obtained from surgical site infections, and in half (in 2 out of 4 strains - 50%) of the *E. coli* strains obtained from sputum during pneumonia (Figure 1).

When analyzing the characteristics of ESBL synthesis in *K. pneumoniae* strains, which are the causative agent of nosocomial infection, ESBL synthesis was determined in 3 (37.5%) of the *K. pneumoniae* strains obtained from urine, in most (in 6 out of 7 strains - 85.7%, $X^2 = 16.72$, $p < 0.05$) of the *K. pneumoniae* strains obtained from surgical site infections and in many (3 out of 5 strains - 60%) of the *K. pneumoniae* strains obtained from the sputum of pneumonia patients (Figure 2).

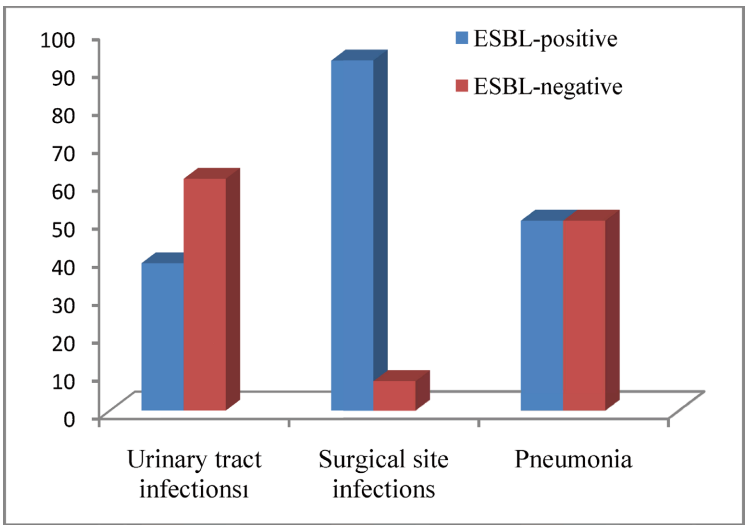

Figure 1. Characteristics of extended-spectrum beta-lactamase synthesis in Escherichia coli strains (the number of strains on the ordinate axis is shown as a percentage).

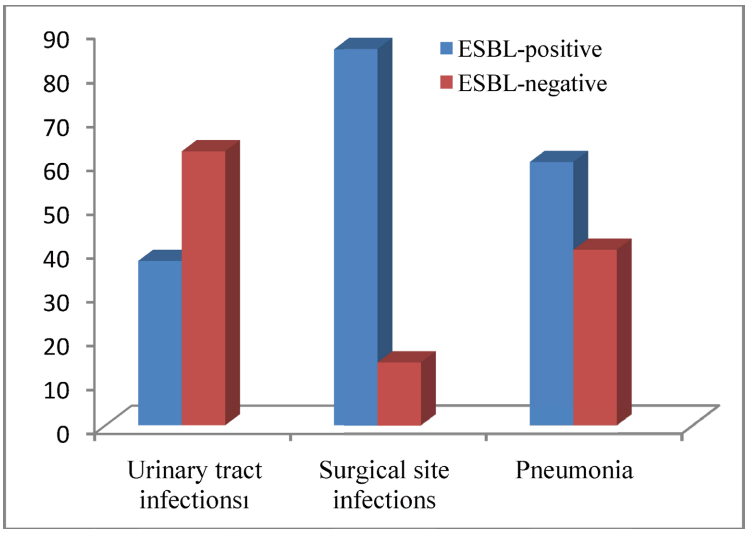

Figure 2. Characteristics of ESBL synthesis in *Klebsiella pneumoniae* strains (the number of strains on the ordinate axis is shown as a percentage).

4. Discussion

When analyzing the characteristics of ESBL synthesis in *E. coli* strains, which are the causative agent of nosocomial infection, it is found that while ESBL synthesis was observed in most (92.3%) of the strains obtained during surgical site infections, a small number (38.9%) of strains obtained from patients with urinary tract infections have ESBL positivity. Such a feature of ESBL synthesis in *E. coli* strains can be explained by the organotropism of these bacteria, as it is known that urinary tract infections are caused by uropathogenic *E. coli* in most cases. Since beta-lactam antibiotics are limited in the empiric treatment of urinary tract infections, ESBL synthesis in uropathogenic *E. coli* strains is observed relatively rarely. It is also possible to explain the reasons why most (92.3%) of the strains, which are obtained during surgical site infections, synthesize ESBLs from this point of view. It is known that beta-lactam antibiotics are widely used antibiotics in medical practice. For this reason, resistance to beta-lactam antibiotics is observed in more cases in *E. coli* strains (except uropathogenic *E. coli*) that cause inflammatory processes in other parts of the body.

When analyzing the features of ESBL synthesis in *K. pneumoniae* strains, which are the causative agent of nosocomial infection, it is found that while ESBL synthesis was observed in most (85.7%) of the strains obtained during surgical site infections and in many (60%) *K. pneumoniae* strains obtained from sputum, small number of strains obtained during urinary tract infections (37.5%) had ESBL positivity. It is known that beta-lactam antibiotics are used to a limited extent in empirical treatment of urinary tract infections. Therefore, ESBL synthesis in *K. pneumoniae* strains obtained from urine was observed in relatively few cases. From this point of view, it is also possible to explain the reasons why a large part of *K. pneumoniae* strains obtained from surgical site infections and pneumonia synthesize ESBLs. It is known that beta-lactam antibiotics are widely used antibiotics in medical practice. For this reason, resistance to beta-lactam antibiotics, as well as ESBLs synthesis are observed in relatively more cases in *K. pneumoniae* strains that cause inflammatory processes in other parts of the body.

The obtained results correspond partially to the results of other researches in this field. According to literature data, nosocomial infections caused by ESBL-synthesizing species of the Enterobacteriaceae family are increasing. ESBL activity was studied in 28,894 *E. coli* and 10,903 *K. pneumoniae* strains obtained at the Grosshadern clinic in Germany during 1996-2007. An increase of ESBL-synthesizing *E. coli* strains from 0% to 4.1%, and *K. pneumoniae* strains from 0.3% to 6.6% was determined during these years. Accordingly 20% and 23% of ESBL-positive strains were obtained from surgical patients [1]. In another study, during a regression analysis of nosocomial infections caused by ESBL-positive Enterobacteriaceae in the intensive care units of German hospitals in 2007-2012, it was determined that ESBL-positive Enterobacteriaceae increased by 134% in the etiology of surgical site infections, in urinary tract infections—by 177%, and

in lower respiratory tract infections—by 123% from 2007 to 2012 [2].

In 2011-2012, Escherichia coli strains obtained during bacteremia associated with urinary tract infections, surgical site infections, intra-abdominal abscesses and venous catheters were resistant to ampicillin and amoxicillin combined with β-lactamase inhibitors in 48.1% of cases, and 33.3% of these bacterial strains were ESBL-positive [6] [7]. 11 of 95 *E. coli* strains, which are obtained from surgical site infections in 27 medical centers in Japan, had ESBL activity [8] [9]. ESBL synthesis in *E. coli* and K.pneumonia strains, which are the causative agents of bacteremias observed in 2008-2012, was determined accordingly in 31.3% and 33.8%, 8.8% and 8.4% cases of nosocomial and non-nosocomial bacteremias [10] [11]. 54.8% of 208 cases of bacteremia in a teaching clinic in Hong Kong, China were nosocomial and were caused by *K. pneumoniae*, and ESBL synthesis in these bacterial strains was determined in 15.4% of cases [12].

5. Conclusion

So, ESBL synthesis is widespread in *E. coli* and *K. pneumoniae* strains, which are etiological factors of nosocomial infections. The frequency of occurrence of ESBL-synthesizing strains varies depending on the clinical forms of nosocomial infections.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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