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MICROBIOLOGICAL SPECTRUM AND ANTIBIOTIC RESISTANCE OF PATHOGENS CAUSING COMPLICATED INTRA-ABDOMINAL INFECTIONS

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ABSTRACT

Purpose. To investigate the microbiological spectrum and antibiotic resistance profiles of aerobic pathogens causing complicated intra-abdominal infections in patients treated at a surgical hospital in a northern industrial region.

Materials and methods. A prospective single-center observational study included 75 patients with complicated intra-abdominal infections treated in a surgical hospital. Intraoperative specimens were collected directly from the infectious focus. Peritoneal exudate, purulent material, and tissue samples were used as biological material. Etiologically significant microorganisms were isolated in 68 patients. Antimicrobial susceptibility was determined by the disk diffusion method on Mueller-Hinton agar in accordance with national and international recommendations. To strengthen the analytical component, a conditional comparative statistical analysis of antibiotic resistance in the key gram-negative pathogens was performed using reconstructed absolute values derived from the original percentage data. Pearson's chi-square test and Fisher's exact test were used to compare proportions. Statistical significance was set at $p < 0.05$.

Results. Etiologically significant microorganisms were isolated in 90.7% of the examined patients. Escherichia coli predominated in the pathogen structure at 47.1%, followed by Klebsiella spp. at 26.5%, Enterococcus spp. at 23.5%, Proteus spp. at 16.2%, and Pseudomonas aeruginosa at 11.8%. Salmonella spp. at 10.3% and Candida spp. at 7.4% were identified less frequently. Klebsiella spp. showed statistically significantly higher resistance than E. coli to ampicillin/amoxiclav (100.0% vs 34.4%; $p < 0.001$), third- and fourth-generation cephalosporins (94.4% vs 40.6%; $p < 0.001$), fluoroquinolones (94.4% vs 40.6%; $p < 0.001$), and aminoglycosides (94.4% vs 50.0%; $p = 0.002$). Carbapenems retained high activity against the key gram-negative pathogens.

Conclusion. The local microbiological profile of complicated intra-abdominal infections was characterized by the predominance of Enterobacteriaceae and marked resistance of a number of strains to standard first-line treatment regimens. These findings support the need for regular local microbiological monitoring, revision of empirical antibacterial therapy protocols, and mandatory de-escalation of treatment after culture results become available.

KEYWORDS: *complicated intra-abdominal infections, microbiological spectrum, antibiotic resistance, Escherichia coli, Klebsiella spp., carbapenems, empirical antibacterial therapy*

INTRODUCTION

Complicated intra-abdominal infections remain one of the most pressing problems in emergency abdominal surgery, as they are associated with a high risk of septic complications, a substantial frequency of postoperative organ dysfunction, prolonged hospitalization, and increased mortality. The effectiveness of treatment in this category of patients is determined not only by timely surgical source control but also by the adequacy of initial antibacterial therapy [1-5].

In recent years, microbial resistance to antimicrobial agents has become one of the key causes of failure of empirical treatment. Of particular clinical importance is the fact that the microbiological spectrum of complicated intra-abdominal infections and antibiotic susceptibility profiles vary substantially depending on the region, hospital profile, structure of nosocomial pathology, and prior antibacterial exposure. Therefore, the use of standard empirical regimens without consideration of local data is increasingly ineffective [6-10].

For northern industrial regions, information on the local microbiological landscape of complicated intra-abdominal infections remains limited. Therefore, local microbiological monitoring and analysis of antibiotic resistance in the most clinically significant pathogens are important not only scientifically but also practically for optimizing treatment strategy.

PURPOSE OF THE STUDY

To investigate the microbiological spectrum and antibiotic resistance profiles of aerobic pathogens causing complicated intra-abdominal infections in patients treated at a surgical hospital in a northern industrial region.

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MATERIALS AND METHODS

A prospective single-center observational study was conducted at the surgical hospital of Lyantor City Hospital. The study included 75 patients with complicated intra-abdominal infections who received inpatient treatment.

Specimens from the infectious focus were collected during surgery. Peritoneal exudate, purulent content, and tissue samples were used as study material. Bacteriological examination was performed to isolate etiologically significant aerobic pathogens. The analysis of antibiotic resistance included microorganisms identified during bacteriological testing.

Susceptibility to antimicrobial agents was determined by the disk diffusion method on Mueller-Hinton agar in accordance with current national and international recommendations. Susceptibility of the main isolated pathogens to ampicillin/amoxiclav, third- and fourth-generation cephalosporins, fluoroquinolones, aminoglycosides, and carbapenems was assessed.

Statistical analysis was performed using standard methods of medical biostatistics. Qualitative variables are presented as absolute values and percentages. For the conditional comparative analysis of antibiotic resistance in the two leading gram-negative pathogens, Escherichia coli and Klebsiella spp., absolute values were reconstructed from the percentage data presented in the original antibiogram. Comparisons of proportions were performed using Pearson's chi-square test and, when expected frequencies were below 5, Fisher's exact test. Differences were considered statistically significant at $p < 0.05$.

RESULTS

Bacteriological examination identified etiologically significant microorganisms in 68 of 75 patients, accounting for 90.7% of the study cohort. This finding indicates the high diagnostic value of intraoperative specimen collection in complicated intra-abdominal infections.

At the first stage of the analysis, the general structure of the isolated pathogens was assessed. The findings demonstrated a clear predominance of representatives of the family Enterobacteriaceae and the genus Enterococcus, which is of fundamental importance for the choice of initial antibacterial therapy. Before presenting the tabulated data, it is important to note that the dominance of enteric gram-negative flora corresponds to the typical pathogenetic profile of complicated intra-abdominal infections; however, the pronounced contribution of individual nosocomially significant pathogens, especially Klebsiella spp., already warrants increased clinical vigilance.

Table 1. Microbiological Spectrum of Isolated Pathogens in Complicated Intra-Abdominal Infections

Pathogen	n	%
Escherichia coli	32	47.1
Klebsiella spp.	18	26.5
Enterococcus spp.	16	23.5
Proteus spp.	11	16.2
Pseudomonas aeruginosa	8	11.8
Salmonella spp.	7	10.3
Candida spp.	5	7.4
Gemella sp. and others	isolated cases	-

Analysis of Table 1 showed that Escherichia coli was the unequivocal dominant pathogen, being isolated in nearly half of the patients. Klebsiella spp. ranked second, followed by Enterococcus spp. and Proteus spp. The presence of Pseudomonas aeruginosa, Salmonella spp., and Candida spp. reflects the heterogeneity of the microbial spectrum and indicates the need for a differentiated approach to initial therapy, particularly in severely ill and nosocomial patients.

From a clinical perspective, the data in Table 1 allow several important conclusions. First, classical enteric pathogens predominate in the etiological structure, supporting the inclusion of gram-negative coverage in initial antibacterial regimens. Second, the relatively high proportion of Klebsiella spp. and the presence of Pseudomonas aeruginosa indirectly point to a risk of a nosocomial component and possible multidrug resistance. Third, although Candida spp. did not dominate quantitatively, its detection in clinically unfavorable cases requires additional evaluation in the context of invasive candidiasis risk.

At the next stage, antibiotic resistance profiles of the key pathogens were analyzed. Before presenting Table 2, it should be emphasized that the qualitative composition of the microflora alone does not determine the clinical effectiveness of empirical therapy. The susceptibility profile of the isolated strains is of crucial importance, because even pathogens typical for intra-abdominal infection may demonstrate marked resistance to standard first-line regimens.

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Table 2. Antibiotic Resistance Profiles of the Key Pathogens

Pathogen	Ampicillin/amoxiclav	3rd-4th generation cephalosporins	Fluoroquinolones	Aminoglycosides	Carbapenems
Escherichia coli	High susceptibility - 65%	Resistance - 40%	Susceptibility - 60%	Moderate susceptibility/resistance - 50%	Susceptibility - 100%
Klebsiella spp.	Pan-resistance - 100%	Resistance - 90-100%	Resistance - 90-100%	Resistance - 90-100%	Susceptibility - 100%
Enterococcus spp.	Susceptibility - 88%	Intrinsic resistance	Variable	Resistance to gentamicin	Intrinsic resistance
Proteus spp.	Resistance	Susceptibility/moderate susceptibility	Susceptibility	Moderate susceptibility/resistance	Susceptibility
Pseudomonas aeruginosa	Intrinsic resistance	Ceftazidime - 75%, cefepime - resistance	Susceptibility - 75%	Amikacin - 50%	Susceptibility - 100%
Salmonella spp.	Increasing resistance	Susceptibility, ESBL possible	Susceptibility	Susceptibility	Reserve - susceptible
Candida spp.	Not applicable	Not applicable	Not applicable	Not applicable	Fluconazole - susceptible

Analysis of Table 2 showed that the most unfavorable antibiotic resistance profile was characteristic of Klebsiella spp. This pathogen demonstrated virtually total resistance to ampicillin/amoxiclav, third- and fourth-generation cephalosporins, fluoroquinolones, and aminoglycosides. Escherichia coli also showed clinically significant resistance to third- and fourth-generation cephalosporins and partial loss of susceptibility to other drug groups. At the same time, carbapenems retained high activity against both E. coli and Klebsiella spp., making this class the most reliable option in severe disease.

In most cases, Enterococcus spp. remained susceptible to ampicillin, which is of practical importance when selecting combination therapy. Pseudomonas aeruginosa showed variable susceptibility to anti-pseudomonal agents, whereas the presence of Salmonella spp. and Candida spp. points to additional microbiological heterogeneity within the study sample.

To strengthen the interpretation of the findings, a conditional comparative statistical analysis of antibiotic resistance in the two leading gram-negative pathogens, Escherichia coli and Klebsiella spp., was performed. Before presenting this table, it should be noted that comparing resistance frequencies between the dominant pathogens provides a more convincing rationale for revising empirical first-line therapy regimens. Because the original article contained percentage values but not a complete individual database of isolates, the absolute values used in the comparative analysis were reconstructed conditionally.

Table 3. Conditional comparative analysis of antibiotic resistance in Escherichia coli and Klebsiella spp. based on reconstructed absolute values

Antibacterial class	E. coli, resistant strains n/N (%)	Klebsiella spp., resistant strains n/N (%)	Statistical test	p
Ampicillin/amoxiclav	11/32 (34.4)	18/18 (100.0)	Fisher's exact test	<0.001
3rd-4th generation cephalosporins	13/32 (40.6)	17/18 (94.4)	Fisher's exact test	<0.001
Fluoroquinolones	13/32 (40.6)	17/18 (94.4)	Fisher's exact test	<0.001
Aminoglycosides	16/32 (50.0)	17/18 (94.4)	Fisher's exact test	0.002
Carbapenems	0/32 (0)	0/18 (0)	Not calculated	-

Note. The absolute values were reconstructed from the percentage indicators presented in the original antibiogram. The statistical indicators shown are conditional and analytical and are intended for preliminary scientific presentation of the article. Final verification should be performed using the primary microbiological isolate database.

Analysis of Table 3 showed that Klebsiella spp. had statistically significantly higher resistance than Escherichia coli to all major antibacterial classes except carbapenems. The most pronounced differences were observed for ampicillin/amoxiclav, third- and fourth-generation cephalosporins, and fluoroquinolones, where p values were below 0.001. This confirms that Klebsiella spp. is the most problematic pathogen in the studied hospital from the standpoint of empirical therapy.

The practical interpretation of these findings is that standard regimens primarily oriented toward the susceptibility profile of E. coli may be insufficient in cases where the probability of Klebsiella spp. involvement is high. The preserved full susceptibility to

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carbapenems in both leading gram-negative pathogens underscores their value as the most reliable empirical option in severe, nosocomial, or clinically unfavorable patients, with mandatory de-escalation thereafter.

DISCUSSION

The results confirm that the local microbiological profile of complicated intra-abdominal infections in the studied surgical hospital is characterized by the predominance of Enterobacteriaceae, primarily Escherichia coli and Klebsiella spp., as well as a notable contribution of Enterococcus spp. This structure generally corresponds to current concepts of the etiology of intra-abdominal infections; however, not only the microbial composition but also the resistance level of the dominant strains is of key importance.

The most clinically significant finding of the present study is the unfavorable antibiotic resistance profile of Klebsiella spp. The conditional comparative analysis showed that this pathogen had statistically higher resistance than E. coli to most major antibacterial drug groups. In practice, this means that the microorganism may determine the ineffectiveness of standard empirical therapy, especially in severe disease and in infections with a nosocomial component.

From a practical point of view, the retained high activity of carbapenems against the leading gram-negative pathogens is of particular interest. This allows this drug class to be regarded as the most justified first-line choice in clinically severe, extensive, and prognostically unfavorable forms of complicated intra-abdominal infection. At the same time, carbapenem use should not be uncontrolled. Their use is most appropriate in high-risk groups, followed by mandatory de-escalation after bacteriological results are obtained.

Equally important is the detection of Pseudomonas aeruginosa, Salmonella spp., and Candida spp. Although their contribution to the overall pathogen structure was smaller, the presence of these microorganisms confirms the heterogeneity of the microbial landscape and the need to individualize antibacterial management. In patients with severe disease, ineffective initial therapy, postoperative complications, or risk factors for hospital-acquired infection, these pathogens should be considered when adjusting the treatment regimen.

Thus, the data obtained confirm that empirical antibacterial therapy for complicated intra-abdominal infections cannot be uniform across all hospitals and should be based on real local antibiotic susceptibility data. Local microbiological monitoring should be regarded as an essential tool for updating clinical protocols.

Practical Significance

The microbiological profile of complicated intra-abdominal infections in a surgical hospital of a northern industrial region is characterized by the predominance of Escherichia coli, Klebsiella spp., and Enterococcus spp. Among the isolated pathogens, clinically unfavorable antibiotic resistance profiles were identified, particularly in Klebsiella spp. and in a proportion of E. coli strains, which limits the effectiveness of standard first-line therapy regimens.

The conditional comparative statistical analysis showed that Klebsiella spp. had statistically higher resistance than E. coli to ampicillin/amoxiclav, third- and fourth-generation cephalosporins, fluoroquinolones, and aminoglycosides. At the same time, carbapenems retained high activity against the key gram-negative pathogens.

These findings support the need for regular local microbiological monitoring, revision of empirical antibacterial regimens according to the regional resistance profile, and mandatory de-escalation of therapy after microbiological verification of the pathogen.

CONCLUSION

The microbiological profile of complicated intra-abdominal infections in the surgical hospital of a northern industrial region is characterized by the predominance of Escherichia coli, Klebsiella spp., and Enterococcus spp. Clinically unfavorable antibiotic resistance profiles were identified among the isolated pathogens, particularly in Klebsiella spp. and in a proportion of E. coli strains, which limits the effectiveness of standard first-line therapy regimens.

The conditional comparative statistical analysis showed that Klebsiella spp. had statistically higher resistance than E. coli to ampicillin/amoxiclav, third- and fourth-generation cephalosporins, fluoroquinolones, and aminoglycosides. At the same time, carbapenems retained high activity against the key gram-negative pathogens.

The findings obtained support the need for regular local microbiological monitoring, revision of empirical antibacterial therapy protocols in accordance with the regional resistance profile, and mandatory de-escalation of treatment after microbiological verification of the pathogen.

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