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ETIOLOGICAL STRUCTURE OF ACUTE INTESTINAL INFECTIONS IN CHILDREN BASED ON MULTIPLEX PCR RESULTS



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Annotation

Acute intestinal infections remain one of the most common infectious diseases in pediatric practice. The etiological structure of these infections is diverse and may include viral, bacterial, and mixed pathogens. The aim of this study was to evaluate the etiological structure and clinical features of acute intestinal infections in children using multiplex polymerase chain reaction. The study included 50 pediatric patients diagnosed with acute intestinal infections. Clinical, epidemiological, laboratory, and multiplex PCR data were analyzed. According to multiplex PCR results, mixed infections were detected most frequently - in 22 patients (44.0%). Viral mono-infections were identified in 16 patients (32.0%), while bacterial mono-infections were detected in 12 patients (24.0%). Mixed infections were mainly represented by viral-bacterial associations and were associated with a more severe clinical course, including prolonged diarrhea, repeated vomiting, dehydration, fever, abdominal pain, leukocytosis, and elevated erythrocyte sedimentation rate. The results indicate that multiplex PCR is an important diagnostic method for identifying mixed etiological forms of acute intestinal infections in children and may contribute to optimization of treatment tactics.

Keywords: acute intestinal infections, children, multiplex PCR, mixed infection, viral gastroenteritis, bacterial diarrhea, dehydration.

ЭТИОЛОГИЧЕСКАЯ СТРУКТУРА ОСТРЫХ КИШЕЧНЫХ ИНФЕКЦИЙ У
ДЕТЕЙ ПО РЕЗУЛЬТАТАМ МУЛЬТИПЛЕКСНОЙ ПЦР



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Аннотация

Острые кишечные инфекции остаются одними из наиболее распространённых инфекционных заболеваний в педиатрической практике. Этиологическая структура этих инфекций разнообразна и может включать вирусные, бактериальные и смешанные возбудители. Целью данного исследования являлась оценка этиологической структуры и клинических особенностей острых кишечных инфекций у детей с использованием мультиплексной полимеразной цепной реакции. В исследование были включены 50 пациентов детского возраста с диагнозом острых кишечных инфекций. Были проанализированы клинические, эпидемиологические, лабораторные данные, а также данные мультиплексной ПЦР. Согласно результатам мультиплексной ПЦР, смешанные инфекции выявлялись наиболее часто - у 22 пациентов (44,0%). Вирусные моноинфекции были выявлены у 16 пациентов (32,0%), тогда как бактериальные моноинфекции были выявлены у 12 пациентов (24,0%). Смешанные инфекции были преимущественно представлены вирусно-бактериальными ассоциациями и были связаны с более тяжёлым клиническим течением, включая продолжительную диарею, повторную рвоту, обезвоживание, лихорадку, боль в животе, лейкоцитоз и повышение скорости оседания эритроцитов. Результаты показывают, что мультиплексная ПЦР является важным диагностическим методом для выявления смешанных этиологических форм острых кишечных инфекций у детей и может способствовать оптимизации лечебной тактики.

Ключевые слова: острые кишечные инфекции, дети, мультиплексная ПЦР, смешанная инфекция, вирусный гастроэнтерит, бактериальная диарея, дегидратация.

BOLALARDA O'TKIR ICHAK INFEKSIYALARINING ETIOLOGIK TUZILMASI: MULTIPLEKS PZR NATIJALARI ASOSIDA

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Annotatsiya

O'tkir ichak infeksiyalari pediatriya amaliyotida eng ko'p uchraydigan yuqumli kasalliklardan biri bo'lib qolmoqda. Ushbu infeksiyalarining etiologik tuzilishi xilma-xil bo'lib, virusli, bakterial va aralash qo'zg'atuvchilarni o'z ichiga olishi mumkin. Mazkur tadqiqotning maqsadi multiplex polimeraza zanjir reaksiyasi yordamida bolalarda o'tkir ichak infeksiyalarining etiologik tuzilishi va klinik xususiyatlarini baholashdan iborat bo'ldi. Tadqiqotga o'tkir ichak infeksiyasi tashxisi qo'yilgan 50 nafar bolalar kiritildi. Klinik, epidemiologik, laborator ma'lumotlar hamda multiplex PZR ma'lumotlari tahlil qilindi. Multiplex PZR natijalariga ko'ra, aralash infeksiyalar eng ko'p aniqlangan - 22 nafar bemorda (44,0%). Virusli mono-infeksiyalar 16 nafar bemorda (32,0%), bakterial mono-infeksiyalar esa 12 nafar bemorda (24,0%) aniqlangan. Aralash infeksiyalar asosan virus-bakterial assotsiatsiyalar ko'rinishida bo'lib, og'irroq klinik kechish bilan bog'liq edi, jumladan uzoq davom etuvchi diareya, takroriy qusish, suvsizlanish,



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isitma, qorin og'rig'i, leykotsitoz va eritrotsitlar cho'kish tezligining oshishi kuzatildi. Natijalar multiplex PZR bolalarda o'tkir ichak infeksiyalarining aralash etiologik shakllarini aniqlashda muhim diagnostik usul ekanini va davolash taktikasini optimallashtirishga yordam berishi mumkinligini ko'rsatadi.

Kalit so'zlar: o'tkir ichak infeksiyalari, bolalar, multipleks PZR, aralash infeksiya, virusli gastroenterit, bakterial diareya, dehidratatsiya.

Introduction

Acute intestinal infections are a significant medical and epidemiological problem in children due to their high prevalence, rapid development of dehydration, and risk of complications. In pediatric practice, these infections are among the most common causes of medical visits, hospitalization, and temporary deterioration of the child's general condition. Diarrheal diseases remain an important cause of morbidity among children worldwide, especially in young age groups, where fluid and electrolyte losses may develop rapidly and lead to clinically significant dehydration [6].

The clinical course of acute intestinal infections in children is determined by several factors, including the age of the patient, immune status, nutritional condition, type of pathogen, infectious dose, and timeliness of medical care. Young children are particularly vulnerable because their compensatory mechanisms are not fully developed, and even short-term vomiting or frequent diarrhea can result in dehydration, metabolic disorders, and worsening of general condition. Therefore, early diagnosis and correct assessment of disease severity are essential in pediatric infectious disease practice.

In pediatric practice, early etiological diagnosis is important because treatment tactics differ depending on whether the infection is viral, bacterial, or mixed. Viral infections usually require mainly rehydration therapy, correction of electrolyte imbalance, diet therapy, and symptomatic treatment. In contrast, bacterial infections, especially invasive forms, may require antibacterial therapy depending on the severity of the disease, clinical presentation, and laboratory findings. Incorrect etiological assessment may lead either to delayed antibacterial treatment in bacterial infections or to irrational antibiotic use in viral diarrhea.

The etiological structure of acute intestinal infections includes viruses, bacteria, and, in some cases, combined viral-bacterial associations. Viral pathogens are usually associated with watery diarrhea, vomiting, acute onset, and moderate intoxication. Such infections are often self-limited but may still cause severe dehydration in infants and young children. Bacterial agents more often cause high fever, abdominal pain, inflammatory stool changes, leukocytosis, elevated inflammatory markers, and a prolonged disease course [1, 4].

Mixed infections represent a special clinical and diagnostic problem. In these cases, two or more pathogens may be detected in the same patient, and the clinical picture may combine features of both viral and bacterial intestinal infections. For example, repeated vomiting and watery diarrhea may be accompanied by high fever, abdominal pain, prolonged diarrhea, dehydration, and inflammatory laboratory changes. This makes clinical differentiation more difficult and increases the importance of modern laboratory diagnostic methods.



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Traditional diagnostic methods, such as bacteriological culture and rapid antigen tests, often detect only a limited number of pathogens. Bacteriological culture is useful for identifying bacterial pathogens, but it requires time and may not detect viral agents. Rapid antigen tests are convenient and fast, but their diagnostic spectrum is limited and they may not reveal mixed etiological forms. In contrast, multiplex polymerase chain reaction allows simultaneous detection of several viral and bacterial enteropathogens in a single stool sample [2, 5]. This method is especially important in children with severe, prolonged, recurrent, or atypical acute intestinal infections.

The use of multiplex PCR expands the possibilities of etiological verification and allows clinicians to identify pathogens that may remain undetected by routine diagnostic approaches. This is important not only for individual treatment decisions but also for epidemiological monitoring. Identification of the true etiological structure of acute intestinal infections makes it possible to improve diagnostic algorithms, rationalize antibacterial therapy, and assess the role of mixed infections in disease severity.

In recent years, the use of multiplex PCR has shown that mixed infections may be more frequent than previously assumed. Detection of several pathogens in one patient changes the interpretation of disease severity and may explain prolonged diarrhea, persistent vomiting, more pronounced dehydration, and stronger inflammatory laboratory changes. Therefore, studying the etiological structure of acute intestinal infections using multiplex PCR is clinically relevant and has practical importance for improving the management of children with acute intestinal infections.

Research Aim

The aim of the study was to determine the etiological structure and clinical characteristics of acute intestinal infections in children based on multiplex PCR results, with special attention to the frequency of mixed infections.

Materials and Methods

The study included 50 pediatric patients diagnosed with acute intestinal infections and examined during 2023-2024. All patients had clinical signs of acute intestinal infection, including diarrhea, vomiting, fever, abdominal pain, intoxication, and dehydration of varying severity.

The diagnosis was based on clinical examination, epidemiological history, routine laboratory tests, and etiological verification by multiplex polymerase chain reaction (PCR). Children with acute gastrointestinal symptoms, available stool samples, and complete clinical-laboratory data were included. Patients with chronic gastrointestinal diseases, congenital disorders, immunodeficiency, surgical abdominal pathology, incomplete data, or inability to perform multiplex PCR were excluded.

At admission, general condition, body temperature, stool and vomiting frequency, abdominal pain, hydration status, skin turgor, mucous membrane moisture, urine output, and activity level were assessed. Epidemiological history included contact with infected patients, suspicious food consumption, drinking water source, kindergarten or school attendance, family/group cases, seasonality, and time from disease onset to admission.

Laboratory examination included complete blood count, erythrocyte sedimentation rate, stool examination, and additional tests when indicated. Stool samples were collected during the acute period, preferably before antibacterial therapy, and examined by multiplex PCR.



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According to multiplex PCR results, patients were divided into three groups: viral mono-infection, bacterial mono-infection, and mixed infection. Mixed infection was defined as simultaneous detection of two or more pathogens. Data were analyzed using descriptive statistics and presented as absolute numbers and percentages.

Results and Discussion

A total of 50 children with acute intestinal infections were examined. Multiplex PCR allowed etiological verification of viral, bacterial, and mixed forms of infection.

4.1 Etiological structure according to multiplex PCR

Multiplex PCR results showed that mixed infections were the most common etiological group, detected in 22 patients (44.0%). Viral mono-infections were found in 16 patients (32.0%), while bacterial mono-infections were identified in 12 patients (24.0%). This indicates that mixed etiological forms play an important role in acute intestinal infections among children.

Table 1. Etiological structure of acute intestinal infections in children according to multiplex PCR results

Etiological group	Number of patients	Percentage
Mixed infections	22	44.0%
Viral mono-infections	16	32.0%
Bacterial mono-infections	12	24.0%
Total	50	100%

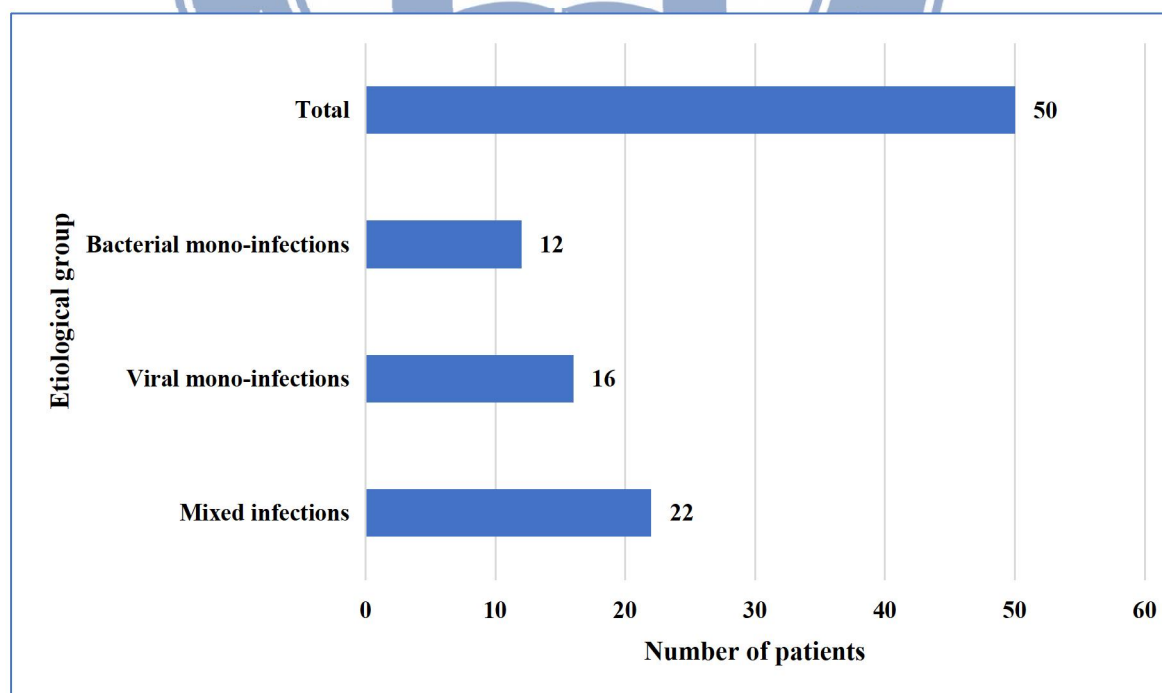


Figure 1. Etiological structure of acute intestinal infections according to multiplex PCR.

The predominance of mixed infections indicates that acute intestinal infections in children may often have a combined etiological nature. This finding also demonstrates the diagnostic value

of multiplex PCR, because mixed infections may remain undetected when only routine bacteriological methods are used.

4.2 Structure of mixed infections

Mixed infections were mainly represented by viral-bacterial associations, which were detected in 15 patients (68.2%). Viral-viral associations accounted for 22.7%, while bacterial-bacterial associations were less common - 9.1%. These findings show that viral-bacterial combinations were the predominant form of mixed infections in children with acute intestinal infections.

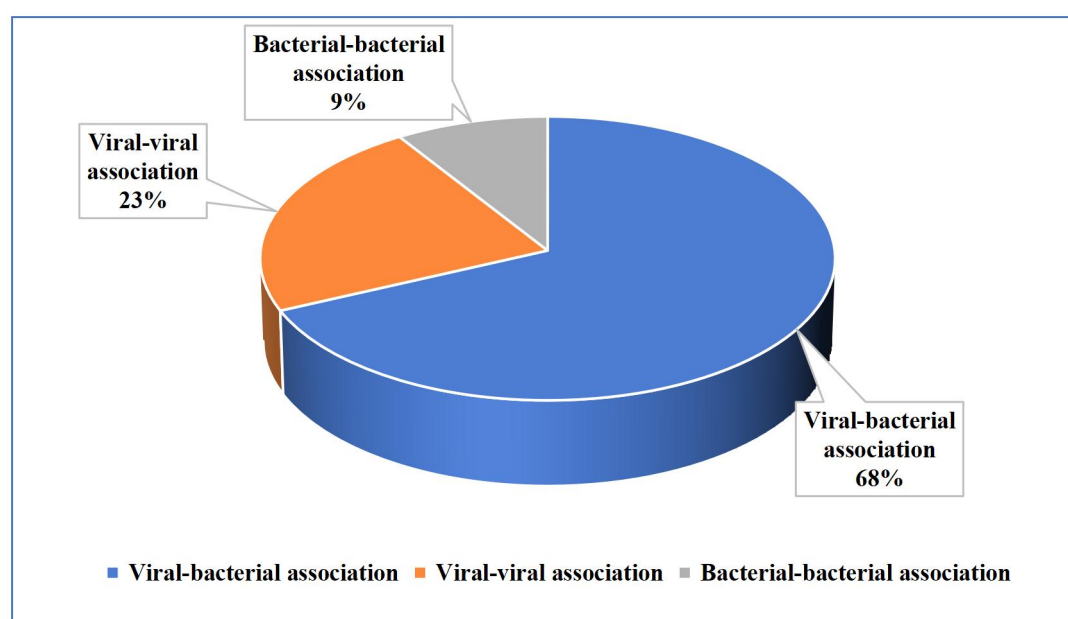


Figure 2. Structure of mixed infections detected by multiplex PCR.

The predominance of viral-bacterial associations suggests that combined pathogen involvement may influence the severity and duration of clinical manifestations.

4.3 Clinical characteristics of patients

The comparative analysis showed that mixed infections had the most pronounced clinical course. In this group, diarrhea lasting more than 3 days was observed in 19 patients (86.4%), dehydration signs in 18 patients (81.8%), fever $\geq 38^{\circ}\text{C}$ in 17 patients (77.3%), and repeated vomiting in 16 patients (72.7%).

Bacterial mono-infections were also associated with severe inflammatory signs, especially fever, abdominal pain, leukocytosis, and elevated ESR. Viral mono-infections were more often characterized by repeated vomiting, while inflammatory laboratory changes were less common. These results indicate that mixed infections may be associated with a more severe and prolonged course of acute intestinal infections in children.

Table 2. Comparative clinical and laboratory characteristics of etiological groups.

Clinical/laboratory sign	Viral mono-infection n=16	Bacterial mono-infection n=12	Mixed infection n=22
Fever $\geq 38^{\circ}\text{C}$	7 / 43.8%	9 / 75.0%	17 / 77.3%



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Repeated vomiting	11 / 68.8%	5 / 41.7%	16 / 72.7%
Diarrhea >3 days	6 / 37.5%	9 / 75.0%	19 / 86.4%
Dehydration signs	7 / 43.8%	8 / 66.7%	18 / 81.8%
Abdominal pain	5 / 31.3%	9 / 75.0%	15 / 68.2%
Leukocytosis	4 / 25.0%	8 / 66.7%	14 / 63.6%
Elevated ESR	5 / 31.3%	8 / 66.7%	13 / 59.1%

Fever $\geq 38^{\circ}\text{C}$ was observed more frequently in bacterial mono-infections and mixed infections, while in viral mono-infections fever was usually moderate. In children with mixed infections, high fever was often combined with repeated vomiting and prolonged diarrhea, which increased the risk of dehydration. Repeated vomiting was most commonly detected in viral mono-infections and mixed infections. In viral cases, vomiting was usually one of the first clinical symptoms, whereas in mixed infections it was more persistent and frequently accompanied by diarrhea lasting more than 3 days.

Diarrhea lasting more than 3 days was most frequent in mixed infections and was observed in 19 of 22 children in this group. In viral mono-infections, diarrhea was usually shorter in duration and mostly watery. In bacterial and mixed infections, diarrhea had a more prolonged course and was sometimes accompanied by mucus or other inflammatory stool characteristics. Dehydration signs were also most common in mixed infections, occurring in 18 patients (81.8%). This may be explained by the combined effect of repeated vomiting, prolonged diarrhea, and fever. Clinically, dehydration was manifested by dry mucous membranes, thirst, reduced urination, weakness, decreased skin turgor, and lethargy.

Laboratory findings showed that leukocytosis and elevated ESR were more frequently detected in bacterial and mixed infections compared with viral mono-infections. These inflammatory changes may help distinguish bacterial or mixed etiological forms from isolated viral diarrhea. However, clinical symptoms and routine laboratory data alone were not sufficient for final etiological diagnosis; therefore, multiplex PCR played the key role in etiological verification.

Discussion

The results of this study showed that mixed infections were the most frequent etiological variant of acute intestinal infections in children examined by multiplex PCR. Mixed infections accounted for 44.0% of all cases, exceeding both viral mono-infections and bacterial mono-infections.

This result is clinically important because routine diagnostic approaches often focus on detecting a single pathogen. However, multiplex PCR makes it possible to identify several pathogens simultaneously. Previous studies have also shown that multiplex PCR improves the etiological diagnosis of infectious gastroenteritis and allows detection of co-infections that may be missed by conventional diagnostic methods [2, 3, 5].

In the present study, viral-bacterial associations predominated among mixed infections. These patients had the most severe clinical manifestations, including prolonged diarrhea, repeated vomiting, dehydration, fever, and abdominal pain. This suggests that combined infection may intensify intestinal inflammation and fluid loss.

The frequency of dehydration was highest among children with mixed infections. This is clinically significant because dehydration is one of the main factors determining disease severity in



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pediatric acute intestinal infections. According to international recommendations, early assessment and correction of dehydration are key components of treatment in children with acute gastroenteritis [1, 6].

Viral mono-infections were more often associated with vomiting and watery diarrhea, while bacterial mono-infections were characterized by fever, abdominal pain, leukocytosis, and elevated ESR. However, mixed infections often included features of both viral and bacterial disease, which may complicate clinical diagnosis.

The findings of this study support the need for wider use of multiplex PCR in children with moderate, severe, prolonged, or clinically unclear acute intestinal infections. Early etiological verification may help avoid unnecessary antibiotic use in viral mono-infections and support rational antibacterial therapy in bacterial or clinically significant mixed infections.

Conclusion

Multiplex PCR revealed that mixed infections were the most common etiological form of acute intestinal infections in children. Among 50 examined pediatric patients, mixed infections were detected in 44.0% of cases, viral mono-infections in 32.0%, and bacterial mono-infections in 24.0%. This finding indicates that acute intestinal infections in children are often not limited to a single pathogen and may have a combined etiological nature.

Mixed infections were mainly represented by viral-bacterial associations. These cases were associated with a more severe clinical course compared with mono-infections. In children with mixed infections, prolonged diarrhea, repeated vomiting, dehydration, fever, abdominal pain, leukocytosis, and elevated ESR were observed more frequently. This suggests that the combined effect of viral and bacterial pathogens may increase the severity and duration of clinical manifestations.

The obtained results show that multiplex PCR is an effective and clinically valuable method for etiological diagnosis of acute intestinal infections in children. Its use allows detection of mixed infections that may remain unidentified by routine diagnostic methods. Multiplex PCR also improves diagnostic accuracy, helps to clarify the etiological structure of the disease, and may contribute to optimization of treatment tactics.

Thus, the use of multiplex PCR in pediatric patients with acute intestinal infections is especially important in moderate, severe, prolonged, and clinically unclear cases. Early identification of viral, bacterial, or mixed etiology can help clinicians choose a more rational treatment approach, avoid unnecessary antibiotic use in viral infections, and provide timely antibacterial therapy when bacterial involvement is clinically significant.

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