Clin. Lab. 2026;72:XXX-XXX

CASE REPORT

Pneumonia in Children Caused by Infection of *Bordetella pertussis* and Two Respiratory Viruses: Case Report and Literature Review

Dan Zhang [1], Dongdong Wu [1], Shanmei Lu [1], Guofeng Mao [1], Guiqin Sun [2], Xiaojiao Zhang [1]

[1] *Department of Clinical Laboratory Center, Shaoxing People's Hospital, Shaoxing, P.R. China*
[2] *School of Medical Technology and Information Engineering, Zhejiang Chinese Medical University, Hangzhou, P.R. China*

SUMMARY

Background: **"Pertussis reappearance" and its epidemic pattern have changed, and the overall incidence group has shifted from infants and children to adolescents and adults.**
Methods: **We use real-time PCR technology for nucleic acid detection of multiple pathogens in respiratory specimens.**
Results: **Children infected with pertussis are prone to coinfection with other pathogens. In February and March of this year, ADV and HRV were highly prevalent in the local area. The child visited the hospital multiple times, increasing the possibility of cross infection, resulting in coinfection of pertussis with ADV and HRV.**
Conclusions: **Early nucleic acid testing for Bordetella pertussis is helpful for the diagnosis of pertussis. Mixed infection pathogens are mainly viral infections. The common mixed infection pathogens in different regions are different and related to the prevalence of local pathogens.**
(Clin. Lab. 2026;72:xx-xx. DOI: 10.7754/Clin.Lab.2025.250447)

Correspondence:
Xiaojiao Zhang
Department of Clinical Laboratory Center
Shaoxing People's Hospital
Shaoxing 312000
P.R. China
Email: 841726829@qq.com

KEYWORDS

Bordetella pertussis, mixed infection, respiratory virus, adenovirus, rhinovirus

INTRODUCTION

Pertussis is a respiratory infectious disease caused by Bp infection. It is highly infectious and mainly infects children. The duration of typical pertussis is long and seriously endangers children's health [1]. The use of DPT combined vaccine has effectively reduced the incidence and mortality of pertussis, but the incidence of pertussis has increased significantly in many countries in recent years, which is called "pertussis reappearance" by some scholars [2]. The main reason is that the coverage of vaccination for older children, adolescents, and adults is insufficient, and as the adult pertussis infection rate increases, patients with spastic cough or protracted cough are increasingly seen in clinic.
The traditional view of infectious diseases focuses on a single infection. However, the impact of simultaneous or secondary infection of other pathogens on the disease

Case Report accepted April 29, 2025

condition and prognosis deserves clinical attention. Pertussis is no exception. It is reported that there may be synergistic bacterial and viral infections after pertussis infection. The pathogens of these mixed infections include Mycoplasma pneumoniae, parainfluenza virus, respiratory syncytial virus, adenovirus, and influenza A and B viruses [3]. However, the reports mainly focus on the mixed infection of one pathogen, and the reports of combined infection of two respiratory viruses are rare. Now we report a case of pneumonia caused by mixed rhinovirus and adenovirus infection with Bp.

CASE REPORT

The 12-year-old child presented with low fever, the highest temperature was 38.2℃, accompanied by paroxysmal continuous cough for half a month, severe cough accompanied by chest pain, mainly at night, no cockcrow like echo at the end of cough, and the child had a history of rhinitis in the past. The specific diagnosis and treatment process is as follows: on the second day of fever with cough, the child took azithromycin by himself for 2 days, but the symptoms did not improve, so he came to our hospital for treatment. The complete blood cell count (CBC) showed WBC 11.85 x 10^9/L, the neutrophil ratio 51.9%, and CRP 0.93 mg/L was given azithromycin intravenously for 2 days, budesonide, terbutaline, and ipratropium bromide atomized inhalation for 3 days. On the 6th day, the child still had low fever and his cough did not improve. He came to the hospital again. The plain CT scan of the chest showed multiple inflammatory lesions of right lung (Figure 1), CBC showed WBC 6.94 x 10^9/L, neutrophil ratio 58.7%, CRP 8.92 mg/L. The diagnosis was pneumonia. Dexamethasone 5 mg intramuscular injection was given to reduce fever. Azithromycin was given intravenously for 3 days, and budesonide and epinephrine were nebulized and inhaled for 3 days. On the 15th day, the child still had low fever with cough, and came to the hospital again. CBC showed WBC 11.04 x 10^9/L, CRP 0.25 mg/L, so he was hospitalized. After admission, according to the results of nucleic acid detection (throat swabs) of various pathogens in the respiratory tract (Table 1), loratadine 10 mg QN was given to reduce airway reactivity, beclomethasone propionate, ipratropium bromide, and terbutaline were inhaled to stop cough. After three days of treatment, the child still had cough. The DNA test result of Bordetella pertussis was positive. He was immediately moved to the isolation ward and treated with oral azithromycin for five days. After five days, the cough of the child improved. The DNA result of Bordetella pertussis was negative. He was discharged from the hospital.

DISCUSSION

According to the Chinese guideline for the diagnosis, treatment, and prevention of pertussis (version 2024), azithromycin is recommended to be the first choice for empirical treatment of pertussis, with oral administration being preferred and intravenous administration being the second choice. See Table 2 for the usage and dosage of azithromycin. In this case, the child had many visits to the hospital, and the clinicians did not use azithromycin canonically, which resulted in the prolonged course of the disease and increased the probability of mixed infection and drug-resistant bacteria. Therefore, it is particularly important to improve clinicians' understanding of pertussis, improve etiological diagnosis, and standardize treatment as soon as possible. Pertussis vaccination is still the most effective measure to prevent and control pertussis. At present, the recommended DTP immunization program in China is three doses of basic immunization at the age of 3, 4, and 5 months, and one dose of booster immunization at the age of 18 - 24 months, which has a good protective effect on preschool children and school-age children who have completed basic immunization or not long after the completion of booster immunization. However, the current epidemic pattern of pertussis has changed, and the overall incidence group has shifted to adolescents and adults. Therefore, strengthening the immunization of adolescents and adults is an important measure to prevent and control the epidemic of pertussis.

Previous studies have reported that there is no significant difference in the clinical severity between children with simple infection and mixed infection of Bp. However, patients with mixed infection have longer cough duration, leukocytes, and lymphocytes in CBC are more likely to rise, and the length of hospital stay of critically ill patients is longer [4,5]. Compared with simple infection with Bp, children with mixed infection are more likely to have cyanosis [6]. Therefore, it is particularly important to strengthen the pathogen monitoring of pertussis mixed infection. In the past decade, there have been many reports on the mixed infection of pertussis at home and abroad. Children with pertussis often infected with other pathogens, including viruses, bacteria, and atypical pathogens, but the mixed infection rate varies greatly based on different research objects, methods, and years (31.6% - 97.2%) (Table 3); therefore, the common mixed infection pathogens in different reports are different. HRV is often the first mixed infection virus, and it has also been shown that the most common mixed infection virus is RSV. Pertussis in children is often mixed with other pathogens, which may be related to many reasons. Due to their immature airway development, unsound immune mechanism, and low immunoglobulin content, pertussis in children is more likely to be complicated with other respiratory pathogens. It is reported in the literature that pertussis toxin can make lymphocytes from thymus, spleen, and lymph nodes enter the peripheral blood in large quantities. When sec-

Table 1. Nucleic acid detection results of multiple pathogens in respiratory tract.

Project	Result	Reference	Project	Result	Reference
HMPV	negative	negative	PIV	negative	negative
InfA	negative	negative	ADV	positive	negative
InfB	negative	negative	HRV	positive	negative
RSV	negative	negative	CP	negative	negative
Cov hBoV	negative negative	negative negative	MP	negative	negative

HMPV Human metapneumovirus, InfA Influenza A virus, InfB Influenza B virus, RSV Respiratory syncytial virus, Cov Coronavirus, hBoV Human bocavirus, PIV Parainfluenza virus, ADV Adenovirus, HRV Human rhinovirus, CP *Chlamydia pneumoniae,* MP *myco-plasma pneumoniae.*

Table 2. Usage and dose of azithromycin in the treatment of pertussis.

Age	First day dose	Day 2 - 5 dose	Course of treatment
< 6 months	10 mg/kg/d		5 days
> 6 months	10 mg/kg (max 500 mg)	5 mg/kg (max 250 mg)	5 days
adult	500 mg	250 mg/d	5 days

Table 3. Incidence and pathogens of mixed infection in children with pertussis infection at home and abroad.

Author	Region	Time	Age	Method	Number of pertussis	Mixed infection rate (%)	Constituent ratio of mixed infection (%)
Yang SY et al. 2019 [9]	Beijing	2016.11 - 2017.05	< 5	FilmArray RP2	42	61.9	HRV(50) RSV(18.75) PIV(12.5) ADV(12.5) InfA(6.25)
Tao Y et al. 2019 [10]	Shanghai	2016.12 - 2017.11	≤ 9	FilmArray RP2	49	71.4	HRV(38.5) PIV(24.5) RSV(16.3) Cov(14.3) ADV(14.1) HMPV(2.0)
Ma ZY et al. 2017 [11]	Shenzhen	2011.01 - 2013.12	< 1	PCR Bacterial culture	142	97.2	KPN(33.6) SA(12.3) EBV(5.0) CMV(4.2) RSV(4.2) MP(10.1) E.col(9.2) ABA(7.2) HPI(7.2) Hib(4.1) SP(2.9)
Jiang WJ et al. 2021 [4]	Suzhou, Jiangsu	2017.01 - 2019.12	< 2	PCR	202	40.1	HRV(33.6) hBov(18.7) PIV(13.1) InfA/B(3.3) RSV(5.6) HMPV(2.2)
Peng XK et al. 2020 [12]	Xi'an, Shaanxi	2017.01 - 2018.12	1 - 12	PCR Bacterial culture	686	37	RSV(23.2) InfB(23.2) MP(14.1) SP(10.8) ADV(12.4) PIV(11.2) EBV(5.1)
Mihara Y et al. 2021 [13]	Japan	2014.11 - 2018.12	< 1	PCR	10	80	RSV(55.6) HRV(33.3) HMPV(11.1)
Lamrani HanchiA et al. 2021 [14]	Morocco	2018.01 - 2019.12	< 14	FilmArray RP2	31	64.5	HRV(70.0) Cov(25.0) ADV(5.0)
Iglesias L et al. 2021 [15]	Spain	2008.01 - 2016.12	< 5	PCR	57	31.6	HRV(52.7) PIV(17.6) RSV(11.7) ADV(6.0) InfC(6.0) CMV(6.0)

CMV Cytomegalovirus, EBV Epstein Barr virus, HMPV Human metapneumovirus, InfA Influenza A virus, InfB Influenza B virus, InfC Influenza Bvirus, RSV Respiratory syncytial virus, Cov Coronavirus, hBoV Human bocavirus, PIV Parainfluenza virus, ADV Adenovirus, HRV Human rhinovirus, CP *Chlamydia pneumoniae,* MP *mycoplasma pneumoniae,* KPN *Klebsiella pneumoniae,* SA *Staphylococcus aureus,* SP *Streptococcus pneumoniae,* ABA *Acinetobacter baumannii,* HPI *Haemophilus parainfluenzae,* Hib *Haemophilus influenzae,* E. col *Escherichia coli.*

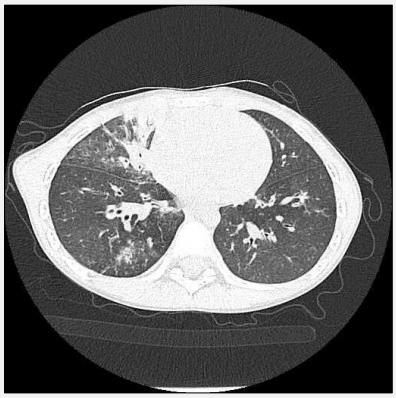

Figure 1. The plain CT scan of the chest.

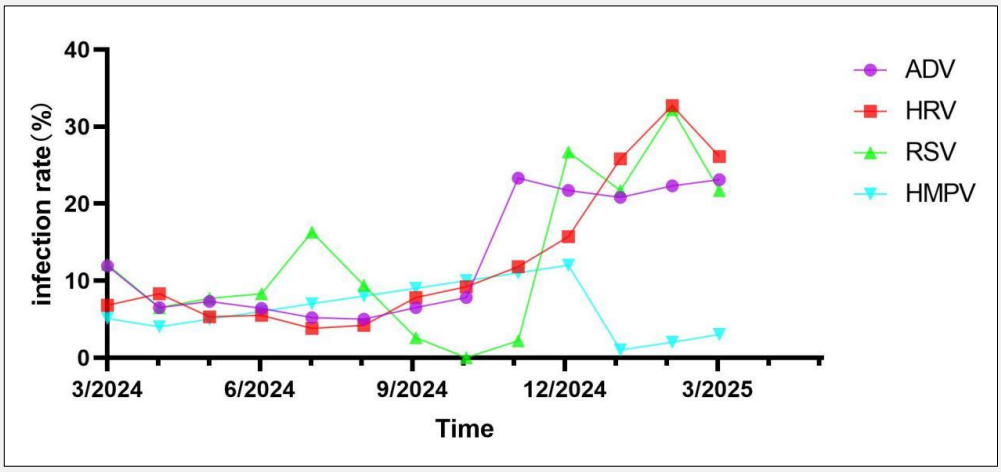

Figure 2. Results of nucleic acid detection of respiratory tract pathogens with high infection rate in our hospital from March 2024 to March 2025.

ondary infection occurs, macrophages and lymphocytes migrate to other infection sites and reduce the body's immunity to other viral and bacterial infections [7]. Pandolfi E et al. [8] studied the expression of cytokines in nasopharyngeal secretions of pertussis patients with HRV infection, and the results showed that pertussis patients with HRV infection support bacterial co-infection through the promotion of the activation of type I interferons (IFNs) and release of pro-inflammatory cytokines. It is suggested that the chronic inflammation caused by one infection further induces the mixed infection of another pathogen. In addition, pertussis has a long course, children may repeatedly enter and leave the hospital, and the risk of mixed infection increases. In this case, it is impossible to judge the sequence of the mixed infection of pertussis with two respiratory viruses. Empirical observation and the distribution of the disease duration suggest that pertussis is the first infection, but it still needs systematic research. The child was infected with ADV and HRV at the same time, which may be related to the epidemiology of the region at that time. We counted the nucleic acid results of respiratory

tract pathogens with a high infection rate detected in our hospital from March 2024 to March 2025 (Figure 2). According to the statistical results, ADV and HRV were highly prevalent in February and March this year, and the children came to the hospital many times increasing the probability of cross infection.

In conclusion, pertussis is not uncommon at present, and early nucleic acid detection of *Bordetella pertussis* is helpful for the diagnosis of pertussis. In addition, children with pertussis are more likely to be infected with other pathogens. The mixed infection pathogens are mainly viral infections. The common mixed infection pathogens in different regions are different, which is related to the local pathogen prevalence. It is of great significance to clarify whether children with pertussis have other respiratory pathogen infections for the study of their epidemiological rules, pathogenic mechanisms, and the selection of clinical treatment plans.

Compliance with Ethical Standards:

All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from the patient for the publication of this case report.

Declaration of Interest:

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

References:

1. Nieves D J, Heininger U. *Bordetella pertussis*. Microbiol Spectr 2016;4(3). (PMID: 27337481)

2. Barkoff A, Grondahl-Yli-Hannuksela K, He Q. Seroprevalence studies of pertussis: what have we learned from different immunized populations. Pathog Dis 2015;73(7):ftv050. (PMID: 26208655)

3. Heininger U, Burckhardt M. Bordetella pertussis and concomitant viral respiratory tract infections are rare in children with cough illness. Pediatr Infect Dis J 2011;30(8):640-4. (PMID: 21407144)

4. Jiang W, Mao L, Wang K, et al. Prevalence of B. pertussis infection in children with clinically suspected pertussis. J Microbiol Immunol Infect 2021;54(4):693-700. (PMID: 32245724)

5. Liu Y, Zhang Y, Xu Q, et al. Infection and co-infection patterns of community-acquired pneumonia in patients of different ages in China from 2009 to 2020: a national surveillance study. Lancet Microbe 2023;4(5):e330-e339. (PMID: 37001538)

6. Tozzi A E, Del Chierico F, Pandolfi E, et al. Nasopharyngeal microbiota in hospitalized children with *Bordetella pertussis* and Rhinovirus infection. Sci Rep 2021;11(1):22858. (PMID: 34819600)

7. Sawal M, Cohen M, Irazuzta JE, et al. Fulminant pertussis: a multi-center study with new insights into the clinico-pathological mechanisms. Pediatr Pulmonol 2009;44(10):970-80. (PMID: 19725100)

8. Pandolfi E, Panera N, Alisi A, et al. Cytokine expression patterns in hospitalized children with *Bordetella pertussis*, Rhinovirus or co-infection. Sci Rep 2021;11(1):10948. (PMID: 34040002)

9. Selbuz S, Ciftci E, Ozdemir H, Guriz, H, Ince E. Comparison of the clinical and laboratory characteristics of pertussis or viral lower respiratory tract infections. J Infect Dev Ctries 2019;13(9): 823-30. (PMID: 32074092)

10. Tao Y, Tang M, Luo L, et al. Identification of etiologic agents and clinical characteristics for patients suspected of having pertussis in a large Children's Hospital in China. Ann Transl Med 2019;7(18):443. (PMID :31700879)

11. Huang H, Deng L, Xiao F, et al. [Clinical analysis of children with pertussis and significance of respiratory virus detection in the combined diagnosis]. Zhonghua Er Ke Za Zhi 2017;55(8): 580-5. (PMID: 28822432)

12. van Wijhe M, Johannesen C K, Simonsen L, Jorgensen IM; RESCEU Investigators; Fischer TK. A Retrospective Cohort Study on Infant Respiratory Tract Infection Hospitalizations and Recurrent Wheeze and Asthma Risk: Impact of Respiratory Syncytial Virus. J Infect Dis 2022;226(Suppl 1):S55-S62. (PMID:35426942)

13. Mihara Y, Yoshino S, Nakatani K, et al. *Bordetella pertussis* is a common pathogen in infants hospitalized for acute lower respiratory tract infection during the winter season. J Infect Chemother 2021;27(3):497-502. (PMID: 33303359)

14. Lamrani Hanchi A, Guennouni M, Rachidi M, et al. Epidemiology of Respiratory Pathogens in Children with Severe Acute Respiratory Infection and Impact of the Multiplex PCR Film Array Respiratory Panel: A 2-Year Study. Int J Microbiol 2021;2021: 2276261. (PMID: 35003265)

15. Iglesias L, Casabella Pernas A, Hernandez Febles M, Colino Gil E, Eisman Maraver A, Pena Lopez MJ. Clinical-epidemiological study of *Bordetella pertussis* infection in the Gran Canaria island in the period 2008 - 2016. An Pediatr (Engl Ed) 2018;89(3):170-5. (PMID: 32337323)