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БОКАВИРУС ЧЕЛОВЕКА КАК САМОСТОЯТЕЛЬНЫЙ ПАТОГЕН ПРИ ТЯЖЕЛОЙ ИНФЕКЦИИ НИЖНИХ ДЫХАТЕЛЬНЫХ ПУТЕЙ: ОБЗОР КЛИНИЧЕСКОГО СЛУЧАЯ

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HUMAN BOCAVIRUS AS AN INDEPENDENT PATHOGEN IN SEVERE LOWER RESPIRATORY TRACT INFECTION: A CASE-INTEGRATED REVIEW

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Резюме. На примере клинического случая 1-летней девочки (Минск) была изучена роль бокавируса человека (HBoV) в качестве самостоятельного возбудителя тяжелой пневмонии, имитирующей опухоли легких и средостения. Клинические данные сопоставляются с данными современной литературы, описывающими механизмы повреждения альвеол посредством клеточной пироптоза и ингибирования путей интерферона I типа.

Ключевые слова: бокавирус человека, тяжелая пневмония, пироптоз, дыхательная недостаточность.

Resume. Using the clinical case of a 1-year-old female (Minsk), the role of human bocavirus (HBoV) as an independent causative agent of severe pneumonia mimicking lung and mediastinal tumors was studied. Clinical findings are correlated with contemporary literature mapping out alveolar damage via cellular pyroptosis and type I interferon inhibition pathways.

Keywords: human bocavirus, severe pneumonia, pyroptosis, respiratory failure.

Relevance. Acute respiratory infections continue to dominate pediatric emergency admissions globally. Human Bocavirus 1 (HBoV-1) is routinely isolated from nasopharyngeal samples in children presenting with acute wheezing, bronchitis, and severe parenchymal consolidation. Historically, establishing HBoV-1 as a primary driver of high-grade morbidity has been obscured by high co-infection rates–ranging from 17% to 85% with secondary viral or bacterial targets. This epidemiological pattern has led clinicians to label HBoV as an innocent bystander or a long-lasting «passenger» virus rather than a highly destructive tissue pathogen.

Dismissing the autonomous virulence of HBoV introduces a major clinical hazard. Acute, high-load HBoV mono-infections can trigger dense, bilateral lung consolidations, structural interstitial distortions, and significant radiographic darkening of the superior mediastinum. In infants and young toddlers, this presentation can accurately mimic expanding thoracic lymphoproliferative malignancies or aggressive blastomatous processes. When front-line medical teams fail to recognize that a single, bocavirus can cause such extensive tissue destruction, vulnerable pediatric patients are easily misdiagnosed, exposing them to invasive open thoracic biopsies, prolonged exploratory surgeries, or unnecessary oncological treatments. Recent epidemiological cohorts underscores its autonomous risk

profile; data compiled by Liao, J. et al. highlights that HBoV acts as a sole pathogen in approximately 5.88% of severe pediatric pneumonias, with up to 27.7% of those cases presenting with intensive lobar or segmentary lung consolidation [1]. Exploring the molecular mechanisms of tissue destruction and tracking systemic multi-organ signaling cascades is essential to avoid these diagnostic errors.

Aim: to establish the clinical and radiological profile of Human Bocavirus acting as a direct, independent causative agent of severe pneumonia in infants, and to delineate the underlying molecular mechanisms driving its pulmonary and systemic manifestations.

Objectives:

1. To evaluate the clinical, laboratory, and radiographic progression of a confirmed HBoV mono-infection in a one-year-old female patient presenting with severe lower respiratory tract disease and multi-organ involvement.
2. To utilize high-sensitivity molecular diagnostics to systematically exclude standard viral and atypical bacterial co-pathogens, confirming sole HBoV-1 etiology.
3. To contrast case-specific clinical observations with contemporary pathophysiological literature to map host-cell pyroptosis and type I interferon inhibition mechanisms.

Material and methods. A retrospective analysis was conducted on a one-year-old female infant admitted to the «City Children's Infectious Clinical Hospital» in Minsk during the winter period spanning December 2018 and January 2019. The clinical inclusion criteria required the acute presentation of a lower respiratory tract infection accompanied by progressive respiratory failure and systemic extrapulmonary clinical indicators.

To definitively isolate Human Bocavirus as an independent pathogen and validate a sole etiology, an exhaustive microbiological verification matrix was deployed upon admission. This involved high-sensitivity multiplex nasopharyngeal swab polymerase chain reaction (PCR) assays targeting common respiratory entities including Influenza A and B, Respiratory Syncytial Virus (RSV), Adenovirus, Human Metapneumovirus, and Parainfluenza viruses types 1–4, alongside atypical bacterial pathogens such as Mycoplasma pneumoniae and Chlamydia pneumoniae.

Additionally, paired acute-and-convalescent serum immunoglobulins were analysed to rule out bacterial superinfections. Longitudinal chest radiography and contrast-enhanced high-resolution computed tomography (CT) scans of the chest cavity were performed to map the structural evolution of the pulmonary parenchymal changes. Systemic multi-organ involvement was monitored via continuous twelve-lead electrocardiogram (ECG) recording, functional transthoracic echocardiography (TTE) for myocardial evaluation, and comprehensive transabdominal ultrasonography to assess solid organ responses.

Results and their discussion. The patient presented with an acute, hyper-pyretic illness characterized by an unremitting body temperature of up to 39.8°C, marked tachypnea (40 breaths per minute), subcostal retractions, and systemic oxygen saturation (SpO_2) fluctuating between 86% and 88% on room air, establishing Grade 2 respiratory failure. Bilateral auscultation revealed harsh bronchial breath sounds paired with asymmetric crepitations and diffuse expiratory wheezing across both lung fields.

Table 1 summarizes the temporal progression of the core laboratory parameters from admission to the resolution phase of the disease.

Tbl. 1. Longitudinal hematological, biochemical, and functional biomarkers of the patient

Clinical Parameter (Normal Range)	Admission (Day 1)	Mid-Treatment (Day 5)	Prior to Discharge (Day 14)
Hemoglobin (110−130 g/L)	118	101	117
Total Leukocyte Count ($6.0−12.0×10^9$ /L)	$25.7×10^9$ /L	$10.2×10^9$ /L	$8.96×10^9$ /L
Neutrophils (25−45%)	68% (Absolute High)	44%	32%
Lymphocytes (40−60%)	27%	61%	70%
Erythrocyte Sedimentation Rate (4−15 mm/h)	32 mm/h	21 mm/h	8 mm/h
C-Reactive Protein (<5.0 mg/L)	12.9 mg/L	25.8 mg/L	8.4 mg/L
Alanine Aminotransferase (<35 U/L)	9 U/L	10.4 U/L	16 U/L
Aspartate Aminotransferase (<40 U/L)	17 U/L	25 U/L	29.6 U/L
Creatine Kinase-MB (<24 U/L)	36 U/L	46 U/L	47 U/L
PCT (< 0.05 ng/ml)	4.79 ng/ml	0.8 ng/ml	0.08 ng/ml

Initial structural imaging generated atypical and highly alarming findings. Frontal chest radiograph demonstrated extensive, dense patchiness across multiple segments bilaterally. A subsequent contrast-enhanced high-resolution chest CT scan confirmed dense, bilateral polysegmental inflammatory consolidations, focal structural changes resembling chronic fibrotic bands, and clear superior mediastinal darkening. Because these solid parenchymal changes and superior mediastinal masses strongly resembled an expanding lymphoproliferative malignancy or a thoracic sarcoma, an urgent consultation with a pediatric oncologist was requested.

However, the complete infectious disease panel overturned this initial assessment. The high-sensitivity multiplex nasopharyngeal PCR returned completely negative findings for Influenza, RSV, Adenovirus, Parainfluenza, and Human Metapneumovirus. Furthermore, *Mycoplasma* and *Chlamydia* serological profiles, excluded bacterial superinfection. Human Bocavirus-1 was isolated as the absolute sole pathogen, confirming acute HBoV-1 mono-infection. This clinical pattern matches the data from Liao, J. et al. [1], which demonstrated that independent HBoV infections can independently drive severe consolidation and localized airway collapse in a subset of young children [2].

The severe tissue damage and consolidation observed on the patient's CT scans can be explained by examining the molecular pathways triggered by high-load HBoV-1 replication. Unlike most respiratory viruses that undergo quiet apoptotic clearance, HBoV-1 actively initiates the assembly of the intracellular NLRP3 inflammasome inside host alveolar epithelial cells. Fig. 1 illustrates this specific molecular cascade [3].

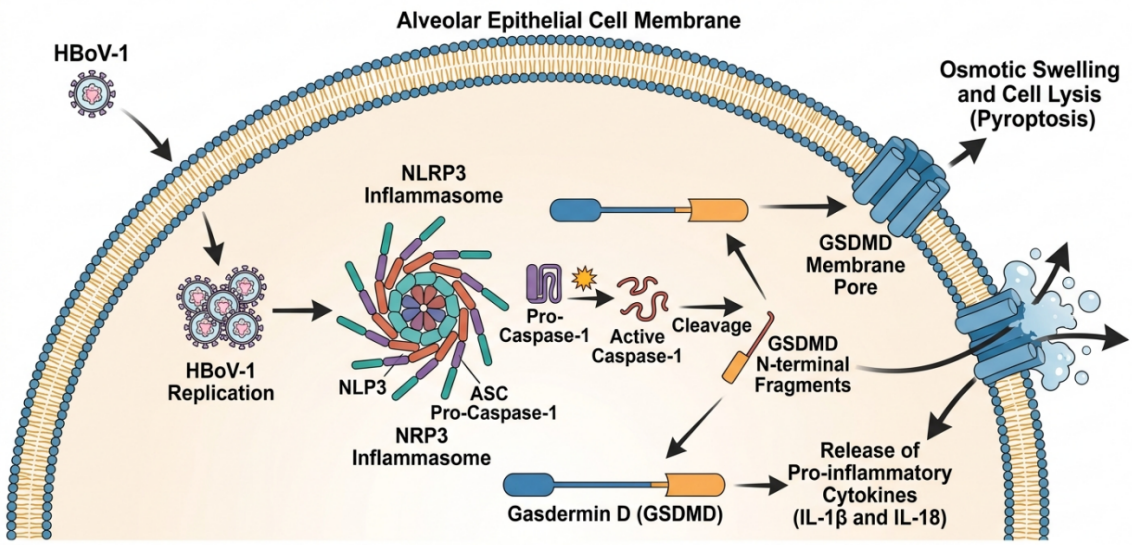

Fig. 1 – Schematics of Human Bocavirus 1 induced alveolar epithelial cell pyroptosis

As detailed in Fig. 1, intracellular replication of HBoV-1 triggers the activation of inflammatory caspase-1. Activated caspase-1 cleaves the structural autoinhibitory domain of Gasdermin D (GSDMD), liberating its cytotoxic N-terminal fragments. These N-terminal fragments translocate to the host cell membrane and oligomerize to form large, unregulated, symmetrical pores through the lipid bilayer.

This pore formation leads to rapid osmotic swelling, cell membrane rupture, and the catastrophic extracellular release of highly potent pro-inflammatory intracellular cytokines, specifically Interleukin-1 beta (IL-1 beta) and Interleukin-18 (IL-18). This lytic cell death mechanism–known as pyroptosis–causes a localized hyper-inflammatory response that damages adjacent alveolar capillary membranes, driving fluid leakage and the extensive tissue consolidation visualized on CT scans. Concurrently, HBoV-1 produces non-structural proteins (NP1 and NS1) that directly block host type I interferon transcription, impairing local mucosal clearance and extending the window of pyroptotic tissue injury [3].

Beyond severe pulmonary disease, our patient exhibited multi-organ involvement: transient hepatomegaly accompanied by gastrointestinal dysfunction marked by loose stools, and secondary myocardial dystrophy confirmed by elevated CK-MB (42 U/L) and echocardiographic evidence of mild left ventricular strain. This multi-organ pattern matches literature showing that pediatric patients aged 6 months to 2 years are uniquely vulnerable to systemic HBoV-1 complications [4].

The systemic effects of HBoV can be contextualized by examining how localized viral infections drive distant vascular and tissue inflammation. Inflammatory pathways that trigger focal arterial and endothelial remodelling–similar to those observed in pediatric vascular disorders like focal cerebral arteriopathy–demonstrate that localized viral activity can cause remote vascular changes. Large-scale systemic cytokine release, paired with high-load HBoV viremia, alters systemic microvascular permeability and inflames distant parenchyma [5]. This mechanism accounts for the transient hepatomegaly, gastrointestinal cell dysfunction, and myocardial dystrophy observed in young children during the peak of infection.

Under an intensive therapeutic regimen consisting of continuous humidified oxygen support, systemic corticosteroids to suppress the pyroptotic hyper-inflammatory state, and

supportive intravenous hydration, the patient demonstrated rapid, step-wise clinical improvement. Fever defervescence occurred within 72 hours, respiratory distress steadily resolved, and cardiac biomarkers normalized. A follow-up thoracic CT scan performed prior to discharge on Day 14 demonstrated complete resolution of the superior mediastinal darkening and substantial clearance of the bilateral consolidations, confirming that the structural anomalies were driven by reversible viral inflammation rather than a malignant process.

Conclusions:

1. Human Bocavirus is a primary, autonomous pathogen capable of precipitating severe, life-threatening lower respiratory tract infections and Grade 2 respiratory failure in infants without requiring viral or bacterial co-pathogens.

2. The radiologic profile of independent HBoV pneumonia is highly complex; its capacity to induce dense polysegmental consolidations and superior mediastinal changes can mimic pediatric thoracic malignancies or chronic fibrotic processes, creating a dangerous diagnostic trap.

3. Mechanistically, HBoV-1 induces severe alveolar destruction through host cellular pyroptosis mediated by the NLRP3-caspase-1-Gasdermin D pathway, combined with viral suppression of type I interferon signaling. This localized response can lead to multi-organ complications, including myocardial dystrophy, hepatomegaly, and digestive tract dysfunction. Early multiplex PCR screening is essential to ensure accurate diagnosis and prevent unnecessary, invasive oncological procedures.

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