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EDITORIAL

Hantavirus : Zoonotic Threat as the causeof Emerging Infectious Diseases

Hantavirus : Ancaman Zoonosis sebagai penyebab penyakit Infeksi Emerging

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Hantavirus is a zoonotic virus belonging to the Orthohantavirus genus, Hantaviridae family, and Bunyavirale order. This virus has the potential to cause emerging infectious diseases with high morbidity and mortality rates.[1-3] New cases are emerging across regions due to environmental changes, urbanization, climate change, and increased human-animal interactions.[4,5] Based on their geographic distribution, these viruses are divided into Old World hantaviruses, commonly found in Asia and Europe and causing Hemorrhagic Fever with Renal Syndrome (HFRS), and New World hantaviruses, found in the Americas and causing Hantavirus Cardiopulmonary Syndrome (HCPS) or Hantavirus Pulmonary Syndrome (HPS). All of these diseases can be fatal if not treated promptly and appropriately.[2,3]

Hantaviruses are single-stranded, negative-polarity RNA viruses with segmented genomes: small (S), medium (M), and large (L) segments. These segments encode the nucleocapsid protein, surface glycoproteins (Gn and Gc), and the RNA-dependent RNA polymerase enzyme, which plays a key role in viral replication. These enveloped viruses are relatively sensitive to heat, detergents, and disinfectants, but can survive for long periods in humid environments, particularly in rodent excreta.[3]

Hantavirus is an enveloped, single-stranded, negative-strand RNA virus. Hantavirus virions are generally spherical, with an average diameter of about 80-120 mm and have a surface structure with a grid-like pattern. This grid-like pattern can reflect glycoprotein projections that extend up to 12 mm from the lipid bilayer.[3,4] (11) This virus has a segmented genome, namely small (S), medium (M), and large (L) segments. These segments each encode the nucleocapsid protein, surface glycoproteins (Gn and Gc), and the RNA-dependent RNA polymerase enzyme, which plays an important role in the viral replication process. This enveloped virus is relatively sensitive to heat, detergents, and disinfectants, but it can survive for quite a long time in humid environments, particularly in the urine, feces, and saliva of rodents.[3]

The primary reservoir of hantaviruses is various rodent species, although some studies have also reported the presence of hantaviruses in moles, shrews, and bats. Each hantavirus species generally has one primary reservoir species that maintains a persistent infection without showing

clinical symptoms. The virus replicates in the reservoir animal and is excreted in urine, feces, and saliva for long periods, thus serving as a source of infection for humans.[3,]

Hantavirus transmission to humans occurs primarily through inhalation of aerosols containing virus particles from the urine, feces, or saliva of infected rodents. In addition to aerosols, transmission can also occur through direct contact with contaminated materials, rodent bites, or through the mucous membranes of the eyes, nose, and mouth. To date, human-to-human transmission has only been shown to occur in limited cases of Andes virus infections in South America. Therefore, most cases of hantavirus are still classified as zoonotic, meaning transmission occurs from animals to humans.[1-3,6]

The risk of infection increases in individuals who live or work in environments with high rodent populations, such as farmers, forestry workers, laboratory workers, military personnel, and communities living in areas with poor environmental sanitation. Cleaning warehouses, barns, empty houses, or long-unoccupied buildings also increases the risk of exposure to virus-containing aerosols. Climate change, deforestation, urbanization, and changes in land use also influence rodent population dynamics, increasing the opportunity for human contact with these reservoirs.[5,7]

The clinical manifestations of hantavirus infection depend on the causative virus. In HFRS, the disease begins with high fever, headache, myalgia, and gastrointestinal disturbances, then progresses to hypotension, bleeding, thrombocytopenia, acute kidney injury, and kidney failure. HCPS is characterized by a prodromal phase of fever, muscle aches, malaise, and gastrointestinal complaints, which then rapidly progresses to noncardiogenic pulmonary edema, severe respiratory distress, cardiogenic shock, and death. The severity of the disease varies. In HCPS, the fatality rate can reach 30–50%, while in HFRS, the rate varies between 1% and 15%, depending on the infecting virus species.[2,5,7]

Diagnosis is established through a history of rodent exposure, clinical symptoms, and laboratory tests. Serological testing using the ELISA method to detect IgM antibodies and elevated IgG titers remains the most widely used method. In addition, viral RNA detection via Reverse Transcription Polymerase Chain Reaction (RT-PCR) can be performed, especially in the acute phase of infection. Hematological tests may reveal thrombocytopenia, leukocytosis, hemoconcentration, and elevated creatinine levels in HFRS cases.[2,7]

To date, there is no specific antiviral therapy or vaccine approved for widespread use in preventing hantavirus infection in humans. Therefore, the management of hantavirus infection still focuses on early detection and supportive therapy aimed at maintaining vital organ function and preventing complications. Management includes monitoring and correction of fluid and electrolyte balance, hemodynamic stabilization, oxygen therapy, mechanical ventilation in patients with respiratory failure, and renal replacement therapy in patients with acute kidney injury or severe renal failure.[2,5,7,8] Several studies have shown that intravenous ribavirin administration in the early phase of Hemorrhagic Fever with Renal Syndrome (HFRS) has the potential to reduce disease severity and mortality. However, scientific evidence on the effectiveness of ribavirin in Hantavirus Cardiopulmonary Syndrome (HCPS) remains limited and shows inconsistent results. Therefore, ribavirin is not recommended as routine therapy for all cases of hantavirus infection, especially in patients with HCPS.[3,5]

Given the lack of specific antiviral therapy or a vaccine for widespread use in humans, prevention is the primary strategy for controlling hantavirus infections. Prevention focuses on reducing human exposure to the viral reservoir through rodent population control, improving environmental sanitation, eliminating food sources and nesting sites, and implementing safe food storage practices to prevent contamination by infected rodent urine, feces, and saliva. For individuals at high risk of exposure, the use of personal protective equipment (PPE), such as gloves, respirator masks (N95 or equivalent), and eye protection, is recommended during cleaning or handling of areas potentially contaminated with rodent excretions.[2,5]

The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) recommend that suspected contaminated areas not be cleaned by direct sweeping or vacuuming, as these actions can generate aerosols containing virus particles and increase the risk of inhalation. Instead, contaminated surfaces are recommended to be first wet cleaned with a disinfectant, such as sodium hypochlorite solution or an appropriate household disinfectant, and then cleaned using wet cleaning methods to minimize the formation of infectious aerosols.[2,3] In addition to implementing individual-level precautions, strengthening epidemiological surveillance systems, early case detection, public education on risk factors and prevention methods, and implementing a One Health approach that integrates human, animal, and environmental health aspects are important components in reducing the risk of hantavirus transmission and preventing future outbreaks.[3,7,9]

China is reported to have the highest incidence of HFRS in the world, with >90% of cases originating there. This disease is endemic, with thousands of new cases per year. Although the incidence has decreased due to vaccination programs, rodent control, and improved environmental sanitation. Similar cases have been reported in Korea, Russia, Finland, Germany, Sweden, Belgium, several Balkan countries, the United States, Canada, Argentina, Chile, Brazil, Paraguay, Bolivia, and Panama. In South America, the only Hantavirus reported can be transmitted to a limited extent from human to human through close contact, although the main source of transmission remains exposure to infected rodents.[1,5,7,9]

In Indonesia, data on the epidemiology of hantavirus is still limited and likely underdiagnosed or underreported because its clinical symptoms resemble other more common infectious diseases, such as leptospirosis, dengue fever, malaria, and sepsis. 5 Seroepidemiological studies have also found antibodies to hantavirus in humans, indicating that exposure to this virus has occurred in the community. Several rodent species such as Rattus tanezumi, Rattus norvegicus, and Rattus exulans have been reported to act as potential reservoirs of hantavirus in Indonesia.[10]

The discovery of hantavirus infection in Indonesia was first reported in 1991 in the city of Maumere in port workers, and was subsequently found in major cities, namely Jakarta, Bandung, Yogyakarta, Semarang, Surabaya, Denpasar and Makassar.[11] In 2018, hantavirus infection in Indonesia originated from German tourists who visited Sulawesi Island.[12] Cases of infection in Indonesia were confirmed in patients with acute fever syndrome and kidney disorders. In addition, several molecular studies have successfully identified the presence of Seoul virus (SEOV) in rodents caught in various regions of Indonesia. Seoul virus is a species of hantavirus that has a global distribution because its main reservoir, namely Rattus norvegicus, is widespread in urban and port

areas. This condition indicates that Indonesia has a potential risk of hantavirus infection, especially in areas with high rodent density and poor environmental sanitation.[10,13]

Prevention efforts are carried out through rodent population control, implementing clean and healthy lifestyles, and strengthening surveillance based on the One Health approach.[2,3,14] Increasing awareness, public education, and cross-sector collaboration are important steps in minimizing the impact of hantavirus disease.[15,16]

REFERENCES

1. Afzal S, Ali L, Batool A, et al. Hantavirus: an overview and advancements in therapeutic approaches for infection. Front Microbiol. 2023;14:1233433. doi: 10.3389/fmicb.2023.1233433
2. World Health Organization. Hantavirus. Geneva: WHO; 2026. Available from: https://www.who.int/news-room/fact-sheets/detail/hantavirus
3. Centers for Disease Control and Prevention. About Hantavirus. Atlanta: CDC; 2024. Available from: https://www.cdc.gov/hantavirus/about/index.html
4. Assadah NS, Sendow I, Dharmayanti NLPI. Hantavirus: Structure, Mechanism of Transmission of Disease, Development of Drugs and Vaccines, and Prevention in Indonesia. WARTAZOA. 2020;30(2):71-8.
5. Jonsson CB, Figueiredo LTM, Vapalahti O. A Global Perspective on Hantavirus Ecology, Epidemiology, and Disease. Clin Microbiol Rev. 2010;23(2):412–41. doi: 10.1128/CMR.00062-09
6. Vaheri A, Strandin T, Hepojoki J, et al. Uncovering the mysteries of hantavirus infections. Nat Rev Microbiol. 2013;11(8):539–50. doi:10.1038/nrmicro3066.
7. Tian H, Stenseth NC. The ecological dynamics of hantavirus diseases: From environmental variability to disease prevention largely based on data from China. PLoS Negl Trop Dis. 2019;13(2):e0006901.
8. Dheerasekara K, Sumathipala S, Muthugala R. Hantavirus Infections—Treatment and Prevention. Curr Treat Options Infect Dis. 2020;12(4):410-21. doi: 10.1007/s40506-020-00236-3
9. Kruger DH, Figueiredo LTM, Song JW, et al. Hantaviruses—globally emerging pathogens. J Clin Virol.2015;64:128–36. doi:10.1016/j.jcv.2014.08.033.
10. Kosasih H, Ibrahim IN, Wicaksana R, et al. Evidence of human hantavirus infection and zoonotic investigation of hantavirus prevalence in rodents in westers Java, Indonesia. Vector Borne Zoonotic Dis. 2011;13(6):709–13.
11. Lukman N, Kosasih H, Ibrahim IN, et al. A Review of Hantavirus research in Indonesia: Prevalence in humans and rodents, and the discovery of Serang Virus. Viruses. 2019;11(698): 1-11.
12. Hofmann J, Weiss S, Kuhns M, et al. Importation of human Seoul virus infection to Germany from Indonesia. Emerg. Infect. Dis. 2018;24(6):1099–1102.
13. Plyusnina AHeyman P, Baert K, et al. Genetic characterization of Seoul hantavirus originated from normay rat (Rattus norvegicus) captured in Belgium. J Med Virol.2012;84(8):1298-303.
14. Romeo MA, Tofani S, Lapa D, et al. Orthohantaviruses: An Overview of the Current Status of Diagnostics and Surveillance. Viruses. 2025;17(5):622.
15. Pan American Health Organization. Hantavirus in the Americas: Guidelines for Prevention, Diagnosis, Treatment, and Control. Washington (DC): PAHO; 1999. Available from : https://iris.paho.org/items/491426f7-d052-470e-a3fd-14b4e62d6b64
16. Jonsson CB, Figueiredo LT, Vapalahti O. A global perspective on hantavirus ecology, epidemiology, and disease. Clin Microbiol Rev. 2010;23(2):412–41.

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by Husnun Amalia FK

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REFERENCES

1. Afzal S, Ali L, Batool A, et al. Hantavirus: an overview and advancements in therapeutic approaches for infection. Front Microbiol. 2023;14:1233433. doi: 10.3389/fmicb.2023.1233433
2. World Health Organization. Hantavirus. Geneva: WHO; 2026. Available from: https://www.who.int/news-room/fact-sheets/detail/hantavirus
3. Centers for Disease Control and Prevention. About Hantavirus. Atlanta: CDC; 2024. Available from: https://www.cdc.gov/hantavirus/about/index.html
4. Assadah NS, Sendow I, Dharmayanti NLPI. Hantavirus: Structure, Mechanism of Transmission of Disease, Development of Drugs and Vaccines, and Prevention in Indonesia. WARTAZOA. 2020;30(2):71-8.
5. Jonsson CB, Figueiredo LTM, Vapalahti O. A Global Perspective on Hantavirus Ecology, Epidemiology, and Disease. Clin Microbiol Rev. 2010;23(2):412–41. doi: 10.1128/CMR.00062-09
6. Vaheri A, Strandin T, Hepojoki J, et al. Uncovering the mysteries of hantavirus infections. Nat Rev Microbiol. 2013;11(8):539–50. doi:10.1038/nrmicro3066.
7. Tian H, Stenseth NC. The ecological dynamics of hantavirus diseases: From environmental variability to disease prevention largely based on data from China. PLoS Negl Trop Dis. 2019;13(2):e0006901.
8. Dheerasekara K, Sumathipala S, Muthugala R. Hantavirus Infections—Treatment and Prevention. Curr Treat Options Infect Dis. 2020;12(4):410-21. doi: 10.1007/s40506-020-00236-3
9. Kruger DH, Figueiredo LTM, Song JW, et al. Hantaviruses—globally emerging pathogens. J Clin Virol.2015;64:128–36. doi:10.1016/j.jcv.2014.08.033.
10. Kosasih H, Ibrahim IN, Wicaksana R, et al. Evidence of human hantavirus infection and zoonotic investigation of hantavirus prevalence in rodents in westers Java, Indonesia. Vector Borne Zoonotic Dis. 2011;13(6):709–13.
11. Lukman N, Kosasih H, Ibrahim IN, et al. A Review of Hantavirus research in Indonesia: Prevalence in humans and rodents, and the discovery of Serang Virus. Viruses. 2019;11(698): 1-11.
12. Hofmann J, Weiss S, Kuhns M, et al. Importation of human Seoul virus infection to Germany from Indonesia. Emerg. Infect. Dis. 2018;24(6):1099–1102.
13. Plyusnina AHeyman P, Baert K, et al. Genetic characterization of Seoul hantavirus originated from normay rat (Rattus norvegicus) captured in Belgium. J Med Virol.2012;84(8):1298-303.
14. Romeo MA, Tofani S, Lapa D, et al. Orthohantaviruses: An Overview of the Current Status of Diagnostics and Surveillance. Viruses. 2025;17(5):622.
15. Pan American Health Organization. Hantavirus in the Americas: Guidelines for Prevention, Diagnosis, Treatment, and Control. Washington (DC): PAHO; 1999. Available from : https://iris.paho.org/items/491426f7-d052-470e-a3fd-14b4e62d6b64
16. Jonsson CB, Figueiredo LT, Vapalahti O. A global perspective on hantavirus ecology, epidemiology, and disease. Clin Microbiol Rev. 2010;23(2):412–41.