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MONKEYPOX OUTBREAKS: A COMPREHENSIVE REVIEW OF EPIDEMIOLOGY, CLINICAL MANAGEMENT, AND PUBLIC HEALTH RESPONSES

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Abstract. Monkeypox, caused by a zoonotic virus, and has emerged as a significant public health issue, particularly with recent outbreaks extending beyond its traditional endemic areas in Central and West Africa. This virus, which belongs to the Orthopoxvirus genus, is closely related to the variola virus that causes smallpox. The resurgence of monkeypox underscores the urgent need to understand its epidemiology, clinical management, and public health responses, especially given the global spread observed in 2022. Monkeypox primarily transmits from animals to humans, with rodents and monkeys acting as the primary reservoirs. Secondary human-to-human transmission occurs through respiratory droplets or contact with contaminated materials. Clinically, monkeypox manifests with symptoms similar to smallpox, such as fever, rash, and lymphadenopathy, although it is generally less severe. Supportive treatments, including antivirals like tecovirimat, have shown efficacy in alleviating symptoms and reducing disease severity. Additionally, the development of new antiviral agents and treatment protocols remains an area of active research. Vaccination plays a crucial role in managing monkeypox outbreaks. The smallpox vaccine, which provides cross-protection against monkeypox, has been instrumental in controlling the spread of the disease. Public health strategies have emphasized targeted vaccination campaigns, thorough contact tracing, and comprehensive surveillance efforts. These measures highlight the necessity of rapid and coordinated actions to manage and prevent outbreaks effectively. Addressing the global burden of monkeypox requires strengthening healthcare infrastructure, enhancing disease surveillance systems, and fostering international collaboration. Efforts to improve diagnostics, vaccine distribution, and public health education are also vital. By focusing on these areas, the global community can improve its capacity to manage and mitigate the impact of this re-emerging infectious disease. Effective response strategies are essential for controlling current outbreaks and preventing future ones, ultimately reducing the global impact of monkeypox and improving public health outcomes.

Key words: *monkeypox, zoonotic virus, Orthopoxvirus, smallpox vaccine, disease surveillance, public health response.*

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ВСПЫШКИ ОСПЫ ОБЕЗЬЯН: КОМПЛЕКСНЫЙ ОБЗОР ЭПИДЕМИОЛОГИИ, КЛИНИЧЕСКОГО ВЕДЕНИЯ И МЕР ОБЩЕСТВЕННОГО ЗДРАВООХРАНЕНИЯ

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Резюме. Оспа обезьян, вызываемая зоонозным вирусом, стала серьезной проблемой общественного здравоохранения, особенно в связи с недавними вспышками, выходящими за пределы традиционных эндемичных районов Центральной и Западной Африки. Вирус оспы обезьян, принадлежащий к роду *Orthopoxvirus*, близко родственен вирусу натуральной оспы. Появление оспы обезьян подчеркивает настоятельную необходимость понимания ее эпидемиологии, клинического ведения и круга мер общественного здравоохранения, особенно с учетом глобального распространения, наблюдаемого в 2022 г. Оспа обезьян в основном передается от животных к человеку, причем основными резервуарами являются грызуны и обезьяны. Вторичная передача от человека к человеку происходит воздушно-капельным путем или через контакт с зараженными материалами. Клинически оспа обезьян проявляется симптомами, похожими на симптомы натуральной оспы, такими как лихорадка, сыпь и лимфаденопатия, хотя, как правило, она менее тяжелая. Поддерживающее лечение, включая противовирусные препараты, такие как тековиримат, показало эффективность в облегчении симптомов и снижении тяжести заболевания. Кроме того, разработка новых противовирусных препаратов и протоколов лечения остается областью активных исследований. Вакцинация играет решающую роль в борьбе со вспышками оспы обезьян. Вакцина против оспы, которая обеспечивает перекрестную защиту от оспы обезьян, сыграла важную роль в борьбе с распространением этого заболевания. Стратегии общественного здравоохранения подчеркивают необходимость проведения целевых кампаний вакцинации, тщательного отслеживания контактов и комплексных усилий по эпидемиологическому надзору. Указанные меры подчеркивают необходимость быстрых и скоординированных действий для эффективного управления и предотвращения вспышек. Решение проблемы глобальной оспы обезьян требует усовершенствования инфраструктуры здравоохранения, улучшения систем надзора за заболеваниями и содействия международному сотрудничеству. Усилия по улучшению диагностики, распространения вакцин и просвещения в области общественного здравоохранения также имеют жизненно важное значение, благодаря чему мировое сообщество может улучшить возможности по управлению и смягчению последствий этого вновь возникающего инфекционного заболевания. Эффективные стратегии реагирования необходимы для контроля текущих вспышек и предотвращения их в будущем, в конечном итоге уменьшая глобальное воздействие оспы обезьян и улучшая эффективность общественного здравоохранения.

Ключевые слова: *оспа обезьян, зоонозный вирус, ортопоксвирус, вакцина против оспы, надзор за заболеваниями, ответные меры общественного здравоохранения.*

Introduction

A rare but worrying viral zoonotic disease, monkey pox has drawn attention from all around the world recently because of outbreaks that have taken place outside of its traditional endemic regions in Central and West Africa. The virus that causes the disease is the monkey pox virus, which is a member of the Orthopoxvirus genus, which also contains the vaccinia and variola (smallpox) viruses. The necessity for a thorough understanding of monkeypox epidemiology, clinical care, and public health measures is highlighted by the epidemics growing frequency and geographic expansion. According to epidemiological research, rodents and primates are the main animals from whom humans contract monkeypox. Human-to-human transmission can happen when contaminated items, bodily fluids, or respiratory droplets come into contact with one another. The reappearance of monkeypox in non-endemic countries like North America and Europe highlights the significance of international travel and trade in the spread of illness. With cases recorded in more than 50 nations, the global outbreak of 2022 posed a serious threat to public health due to its unusual patterns of transmission and wider demographic effects than those of earlier outbreaks [13]. Clinically, monkeypox manifests as a fever, rash, and lymphadenopathy, just like smallpox. Nonetheless, the illness typically has a lower fatality rate and is less severe. Antivirals like tecovirimat show potential in severe cases, although the majority of treatment consists of supportive measures. Smallpox vaccination provides cross-protection and has been an important technique in controlling outbreaks, especially for high-risk groups like healthcare professionals. In response

to outbreaks of monkeypox, public health measures have prioritized isolation, contact tracing, surveillance, and vaccination programs. The pandemic of 2022 brought to light the significance of prompt action, global collaboration, and focused public health initiatives [11]. To reduce the likelihood of future outbreaks, it is imperative to improve disease surveillance, fortify the healthcare system, and increase public awareness. Gaining a better grasp of the monkeypox virus and its mechanics of transmission is crucial to creating preventative and control strategies that work and eventually lessen the worldwide impact of this resurgent illness.

Table 1. Key components of the monkeypox virus structure

Component	Description
Viral Envelope	Outer layer that protects the virus and helps it enter host cells
Core	Contains the viral DNA and enzymes necessary for replication
Lateral Bodies	Contains proteins important for early stages of infection
Surface Proteins	Help the virus attach and enter host cells
Viral DNA	Double-stranded DNA that carries the genetic material of the virus

The pathogenesis of monkey pox

The monkeypox virus, which causes the disease, is a viral zoonotic that was initially discovered in laboratory monkeys in 1958. The first human case was reported in the Democratic Republic of the Congo (DRC) in 1970, which signalled the start of a periodic but on-going public health issue that would mostly affect Central and West Africa. Monkeypox, which is native to these places, has historically been linked to sporadic outbreaks that are usually limited to rural areas where there is a higher frequency of human-wildlife interaction [5]. But in recent times, there has been a noticeable change in the epidemiological picture of monkeypox, with major outbreaks happening outside of Africa, raising concerns throughout the world. The monkeypox virus has a lipid envelope, a core containing double-stranded DNA, lateral bodies with viral proteins, and surface glycoproteins. These components are essential for viral entry, replication, and infection of host cells (Table 1). Monkeypox pathogenesis begins with the virus entering the body through respiratory droplets, broken skin, or mucous membranes. After entry, the virus undergoes primary replication at the site of inoculation or nearby lymphoid tissues. It then disseminates via the bloodstream (primary viremia), targeting reticulo-endothelial organs such as the spleen, liver, and lymph nodes. Secondary viremia follows, leading to the virus spreading to the skin and mucous membranes, where it causes the characteristic pustular rash. Cellular infection triggers an inflammatory response, contributing to the localized tissue damage and systemic symptoms like fever, lymphadenopathy, and malaise. The virus predominantly infects keratinocytes and endothelial cells, inducing apoptosis and cytopathic effects. Host immune responses, both innate and adaptive, play critical roles in limiting viral replication and resolving infection. However, in immune-compromised individuals or severe cases, extensive viral replication and immune evasion can result in complications, including secondary bacterial infections and encephalitis (Table 2).

Geographic Distribution and Current Epidemics (Table 3)

In the past, monkeypox was mostly limited to Central and West Africa, with the Democratic Republic of the Congo recording the greatest number of cases. Notable outbreaks have also occurred in countries like Nigeria; the Nigerian outbreak of 2017 was especially noteworthy because of its scope and the quantity of exported cases [15]. Still, the most alarming trend in monkeypox epidemiology has been its international dissemination. A major global outbreak in 2022 resulted in an unprecedented rise in infections in non-endemic areas. After being discovered in the UK in May 2022, this outbreak swiftly expanded to several nations in Europe, the Americas, and some regions of Asia. In July 2022, the epidemic was deemed a Public Health Emergency of International Concern (PHEIC) by the World Health Organization

Table 2. Showing pathogenesis of monkeypox

Stage	Process	Key Features
1. Viral Entry	Entry through respiratory droplets, broken skin, or mucous membranes	Initial infection site determined by exposure
2. Primary Replication	Virus replicates at the inoculation site or nearby lymphoid tissues	Local swelling or lymphadenopathy
3. Primary Viremia	Virus enters the bloodstream and disseminates to reticulo-endothelial organs (spleen, liver)	Early systemic symptoms like fever, malaise
4. Secondary Viremia	Virus spreads extensively to skin and mucous membranes	Onset of pustular rash and lesions
5. Immune Response	Activation of innate and adaptive immunity to control viral replication	Fever, lymph node swelling, and lesion healing
6. Tissue Damage	Cytopathic effects and apoptosis in keratinocytes and endothelial cells	Localized damage, rash progression
7. Complications	Potential secondary bacterial infections, sepsis, or encephalitis in severe cases	Observed in immune-compromised individuals

Table 3. Based on the data for the global distribution of monkeypox cases from January 2022 to July 2024, Monkeypox Cases by Country (2022–2024)

Country	Confirmed Cases (2022–2024)	Deaths	Percentage of Global Cases
USA	33 556	N/A	32.6%
Brazil	11 841	N/A	11.5%
Spain	8104	N/A	7.9%
Democratic Republic of Congo	4385	N/A	4.3%
France	4283	N/A	4.2%
Colombia	4256	N/A	4.1%
Mexico	4132	N/A	4.0%
UK	4018	N/A	3.9%
Peru	3939	N/A	3.8%
Germany	3886	N/A	3.8%

Table 4. Overview of monkeypox cases globally

Metric	Details
Total Global Confirmed Cases	102 997
Total Global Deaths	223
Most Affected Regions	African Region (54.9%)
	Region of the Americas (24.2%)

Table 5. India's Monkeypox Situation (2022–2024)

Metric	Details
Total Confirmed Cases in India	30
Cases by Region	Kerala: 15
	Delhi: 15
First Reported Case	14th July 2022 (Kollam, Kerala)
Last Reported Case	27th March 2024 (Kerala)
Current Status	No active cases as of July 2024

(WHO), highlighting the gravity and worldwide scope of the problem [11] (Table 4 and 5). This worldwide outbreak exposed the virus's propensity for spreading widely and brought attention to the shortcomings in the ability of international health agencies to identify and contain such outbreaks. In order to control newly emerging infectious illnesses, international collaboration and prompt public health interventions are critical, as demonstrated by the spread of monkeypox to non-endemic areas.

Dynamics of Transmission

Monkeypox transmission dynamics are intricate, encompassing both human-to-human and zoonotic transmission paths. Direct contact with the blood, body fluids, or skin lesions of infected animals especially rodents and primates, which are thought to be the virus's natural reservoirs is the main method of transmission. Because hunting and eating bush-meat expose people to more possibly sick animals, these activities are major risk factors for zoonotic transmission in Africa [16]. Transmission from person to person can happen via respiratory droplets, direct skin-to-skin contact, or contact with contaminated objects like clothes or bedding. In hospital settings, where intimate contact with patients might facilitate the spread of the virus if appropriate infection control measures are not in place, this route of transmission is especially worrying [1]. A number of variables, including as travel habits, population density, and the use of public health initiatives, affect the dynamics of transmission. With cases being recorded in nations distant from the original site of identification, the 2022 outbreak brought attention to the role that international travel plays in the rapid spread of monkeypox. In addition, the density of urban population played a role in the virus's ongoing spread in non-endemic areas [9] (Table 6).

Epidemiological Monitoring and Documentation

Monitoring monkeypox outbreaks epidemiologically is essential for early detection and control of the disease. Surveillance systems have been set up in endemic areas to track cases and identify possible outbreaks before they happen. However, the necessity for increased surveillance in non-endemic areas has been brought to light by the monkeypox epidemic's global spread [8]. One of the most important aspects of stopping further transmission is being able to promptly identify and isolate infections. Strong reporting procedures and data exchanges between nations and international health organizations are essential components of surveillance systems. In order to guarantee that data on instances of monkeypox are appropriately documented and disseminated worldwide, the WHO and other international health organizations are essential in organizing these efforts. The 2022 outbreak illustrated the value of real-time data sharing in monitoring the virus's spread. Improved surveillance is crucial for the efficient control of monkeypox and the advertence of further outbreaks, as is prompt reporting and data exchange. Monkeypox epidemiology has changed dramatically over time, and the outbreak in 2022 serves as a clear reminder of the virus's propensity for spreading far. To effectively tackle this increasing threat, public health measures must take into account the geographic dispersion, transmission patterns, and significance of epidemiological monitoring [6].

Clinical Management of Monkeypox

A typical progression of symptoms, including fever, lymphadenopathy, and a recognizable rash, characterizes the clinical history of monkeypox. Usually, the rash starts off as flat, discolored patches on the

Table 6. Summarizing the transmission pathways of monkeypox, highlighting both animal-to-human and human-to-human transmission

Transmission Type	Description	Examples
Animal-to-Human	Direct contact with infected animals or materials	– Handling wild animals (rodents, primates) – Contact with animal fluids or lesions – Consumption of undercooked meat
Human-to-Human	Close contact with infected individuals or materials	– Respiratory droplets (prolonged face-to-face contact) – Direct contact with skin lesions or body fluids – Contaminated objects (e.g., bedding, clothing)
Vertical Transmission	Transmission from mother to fetus	– Through the placenta, leading to congenital monkeypox
Indirect Transmission	Contact with contaminated surfaces	– Handling materials or surfaces contaminated by an infected individual

skin called macules. These macules develop into elevated papules, which are then transformed into pustules, which are pus-filled lesions, and vesicles, which are tiny blisters filled with fluid. One important characteristic that sets monkey pox apart from other rash-causing diseases is that the rash frequently starts on the face before moving to other areas of the body, such as the palms and soles [17] (Table 7).

Clinical Presentation and Diagnosis

Monkeypox differs from smallpox in that it presents clinically with an early prodromal phase marked by fever, headache, muscle pains, and lymphadenopathy. In the cervical, axillary, and inguinal regions, lymphadenopathy is more common. A rash develops a few days after the fever starts and goes through the various stages listed above [3]. Centrifugal distribution is typical for the rash, with a larger concentration on the face and extremities, such as the palms and soles. Orthopoxvirus infections are characterized by synchronous lesions, which grow at the same stage concurrently. Laboratory tests are used to confirm the diagnosis of monkeypox. PCR assays, which identify viral DNA from lesion swabs, blood, or other clinical samples, are the main method used in these testing. The gold standard for diagnosing monkeypox is PCR because of its excellent specificity and sensitivity. Additionally, though it is not as frequently employed, electron microscopy can show the virus in vesicular fluid. Serological tests can also be used to detect certain antibodies, but they are not as helpful for acute diagnosis as they are for epidemiological research [3].

Treatment and Supportive Care

Since there isn't a specific antiviral medication approved at the moment, supportive care is the mainstay of management for monkeypox patients in an effort to reduce symptoms and avoid consequences. Keeping hydrated, controlling fever, and taking good care of wounds to avoid secondary bacterial infections are all examples of supportive care. Hospitalization may be required in extreme circumstances, especially for patients with problems or immune-compromised individuals [13]. Antiviral medications, like tecovirimat (marketed as TPOXX), have shown promise in preclinical testing and are presently being assessed for their ability to treat monkeypox. With its particular focus on orthopoxviruses, tecovirimat has gained interest as a possible treatment. Research is currently being conducted to determine how well it works against this resurgent illness. Tecovirimat

Table 7. Representing the clinical symptoms timeline for monkeypox, highlighting the key stages from initial infection to recovery

Stage	Time Frame	Key Symptoms/Characteristics
Incubation Period	5 to 21 days (average 7–14 days)	No visible symptoms, virus is developing inside the body
Prodromal Stage	1 to 5 days	– Fever – Headache – Muscle aches – Fatigue – Swollen lymph nodes
Rash Development Stage	1 to 3 days after fever onset	– Rash begins on face, spreads t o other parts – Lesions evolve from macules to pustules
Lesion Progression	2 to 4 weeks	– Lesions progress through stages: macules → papules → vesicles → pustules → scabs – Rash may be itchy or painful
Crusting & Scabbing	2 to 4 weeks after rash onset	– Lesions crust over and scab – Once scabs fall off, the patient is no longer infectious
Recovery Phase	End of 2- to 4-week period	– Rash heals completely – Scabs fall off – Full recovery with scars in some cases

Table 8. Effectiveness of various interventions in different outbreak scenarios: public health interventions for monkeypox

Intervention	Effectiveness in Containing Outbreaks	Description	Best Applied In
Vaccination	High	Administering vaccines at-risk populations	Pre-exposure and post-exposure cases
Isolation Measures	Moderate	Isolating infected individuals to prevent spread	During outbreak peaks
Contact Tracing	Moderate	Identifying and monitoring contacts of infected people	Early stages of outbreaks
Public Awareness Campaigns	High	Educating communities on prevention and symptoms	All stages, especially during outbreaks
Quarantine	High	Restricting movement of exposed individuals	Large-scale outbreaks
Travel Restrictions	Low to Moderate	Limiting travel to prevent international spread	Early outbreak response

is an antiviral medication that inhibits the growth of the Orthopoxvirus by targeting a protein specific to the virus. It has been used in controlled clinical trials and under compassionate use guidelines, but it is still not a commonly available treatment for monkeypox. Because vaccination has cross-protective effects against monkeypox, it has been used as a preventive measure, especially with the smallpox vaccine (ACAM2000 and JYNNEOS). It has been demonstrated that the smallpox vaccination lessens the frequency and severity of monkeypox, particularly in high-risk groups like medical personnel and those who are close to confirmed cases [4].

Long-Term Effects and Complications

Monkeypox can have serious complications, especially in susceptible groups including young children, expectant mothers, and those with weakened immune systems. If left untreated, secondary bacterial infections of skin lesions are frequent and can result in sepsis. Other serious side effects include encephalitis, an inflammation of the brain that can cause neurological impairments or even death, and pneumonia, which can be brought on by a subsequent bacterial or viral infection. Scarring from the skin lesions is one of the long-term symptoms of monkeypox that can be deformative with negative affect the patient's quality of life. Loss of eyesight may result from corneal infections in some situations. In addition, psychological effects including stigma and post-traumatic stress disorder are potential long-term effects that need to be considered, especially *in situ*ations where there is obvious scarring [2].

Strategies and Reactions in Public Health

In order to effectively combat monkey pox epidemics, public health responses must be comprehensive and well-coordinated, include vaccination, fast reaction, international cooperation, and readiness. Effective methods for managing and containing outbreaks are necessary due to the zoonotic nature of monkey pox and its potential for human-to-human transmission, especially when the virus expands outside conventional endemic zones (Table 8).

Readiness and Reaction Schemes

When it comes to public health responses to monkeypox, preparedness is essential. Creating and executing strong preparation plans enables the quick deployment of staff and resources in the event of an outbreak. These measures usually entail setting up surveillance systems to keep an eye out for cases, gathering the appropriate medical supplies in advance, and educating healthcare professionals on how to recognize and treat monkeypox. The prompt isolation of confirmed cases, contact tracking, and the implementation of quarantine measures to stop further transmission all depend on rapid reaction procedures. Resources are employed effectively and these efforts are harmonized when local, national, and international health institutions effectively coordinate. Public health messaging is necessary to promote awareness and make sure that healthcare systems are prepared to handle cases in non-endemic locations where healthcare providers may not be experienced with monkeypox [7].

Immunizations and Preventative Steps

An important tool for containing monkeypox epidemics is vaccination. Since the smallpox vaccination has been shown to cross-protect against monkeypox, response attempts have made use of it especially the more recent JYNNEOS vaccine. One vaccine strategy is ring vaccination, in which the virus is not disseminated by immunizing close contacts of confirmed patients. In the past, this strategy has worked well to contain the spread of the pandemic. Public health authorities stress the need of preventive actions in addition to immunization. To lower the danger of infection, it is essential to educate the public about avoiding contact with potential animal reservoirs, such as mice and monkeys, and about practicing good hygiene, which includes washing your hands and taking care of your wounds. Prioritized vaccination lists include healthcare professionals and

those in close proximity to animals or infected people. Personal protective equipment (PPE) is also encouraged in order to reduce exposure [14].

International Assistance and Cooperation

International cooperation is necessary for the control and containment of monkeypox epidemics because of their worldwide consequences. The World Health Organization (WHO) is essential to the coordination of international responses, the provision of technical assistance, and the facilitation of international resource and information exchange. The World Health Organization (WHO) is a major role in global health. It organizes efforts to control and limit outbreaks and makes sure that nations have the resources and information needed to deal with newly developing infectious illnesses like monkeypox. The World Health Organization (WHO) has released thorough guidelines for laboratory testing, case treatment, and surveillance. The development of these guidelines has involved close coordination with member states and other international partners, offering crucial support to enhance public health responses and guarantee a cohesive and efficient strategy to contain the disease's spread. It has also coordinated the delivery of vaccinations and antivirals to impacted areas. Furthermore, the World Health Organization (WHO) and other global organizations strive to guarantee fair access to vaccines and treatments, especially for low- and middle-income nations that might not have the means to contain an outbreak. Addressing the issues raised by monkeypox requires forging closer international ties and encouraging collaboration between nations, especially as the virus is still spreading to areas outside of its conventional endemic zones. In order to avoid and mitigate future epidemics and, ultimately, safeguard public health globally, resource sharing and global solidarity are essential [16].

Conclusion

Outbreaks of monkeypox provide serious obstacles to international public health, emphasizing the urgent need for all-encompassing approaches that include clinical management, epidemiological surveillance, and coordinated response preparation. Monkeypox has recently become more commonplace worldwide, especially in areas where it is not endemic. This highlights how the virus is always changing and how easily it may spread. Because of this, the infrastructure supporting public health must be continuously strengthened. This includes having reliable surveillance systems that can identify new instances early and act quickly to address them. In order to lessen the effects of monkeypox, effective clinical management is still essential. Research into antiviral treatments like tecovirimat and supportive care are particularly important for improving patient outcomes. Immunization tactics, in particular the smallpox vaccine, have shown to be essential in stopping epidemics, offering cross-protection against the virus, and defending vulnerable groups. Controlling transmission requires the implementation of public health initiatives, such as educating people about preventive measures and enforcing isolation rules. The new outbreaks' worldwide scope emphasizes how crucial international cooperation and resource sharing are. Particularly in environments with limited resources, organizations like the WHO are crucial for organizing initiatives, offering technical assistance, and guaranteeing fair access to vaccinations and treatments. To enhance diagnostic instruments, provide targeted antiviral therapies, and comprehend the dynamics of monkeypox transmission better, further study is required. Mitigating the effects of monkeypox and averting further outbreaks will require the combination of scientific discoveries with public health protocols. In order to address the persistent and new hazards posed by monkeypox and other zoonotic diseases, international cooperation and a strong public health infrastructure are essential.

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