Monkeypox Transmission and Treatment: A Holistic Review of Indigenous and Modern Therapeutic Systems

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Abstract

Background
Monkeypox, a zoonotic viral disease, has re-emerged as a significant global health concern with increasing outbreaks in non-endemic regions. Although conventional antiviral strategies and vaccines are under development or use, their accessibility and limitations prompt the need to explore complementary approaches.

Objective
To review the epidemiology, clinical manifestations, transmission pathways, and therapeutic strategies for monkeypox, with special emphasis on traditional systems of medicine, including Ayurveda, Unani, Traditional Chinese Medicine (TCM), and African ethnomedicine.

Methods
A narrative literature review was conducted using electronic databases such as PubMed, Scopus, and Google Scholar. Peer-reviewed articles, WHO reports, and classical texts of traditional medicine were assessed to extract data on monkeypox outbreaks, clinical features, and traditional interventions. Selection was based on relevance, credibility, and recency.

Results
Monkeypox is transmitted through zoonotic contact, respiratory droplets, direct contact with lesions, and fomites. Clinical presentation mimics smallpox but is typically less severe. While antiviral agents like Tecovirimat and Brincidofovir show promise, traditional medicinal systems offer various plant-based remedies with antiviral, immunomodulatory, and anti-inflammatory effects. Herbs such as Tinospora cordifolia, Glycyrrhiza glabra, Nigella sativa, and Andrographis paniculata demonstrate potential roles in symptomatic relief and immunity enhancement.

Conclusion
Integrative approaches that combine modern pharmacotherapy with validated traditional interventions could strengthen monkeypox management, particularly in resource-limited settings. Further clinical and pharmacological studies are essential to validate these traditional formulations. A multidisciplinary approach may pave the way for a more inclusive and sustainable healthcare response to emerging zoonotic threats.

Keywords

Ayurveda, *Curcuma longa*, Monkeypox virus, Nigeria, Monkeypox, Traditional Medicine, Integrative Medicine

List of abbreviations

MPV, Monkeypox Virus; CA, Congo Basin; WA, West Africa; WHO, World Health Organization; DNA, Deoxyribose Nucleic Acid; CDS, Center for Disease Control and Prevention; RNA, Ribose Nucleic Acid; SARS-COV-2, Severe Acute Respiratory Syndrome Coronavirus -2; DRC, Democratic Republic of the Congo; CDR, Case Death Rate; NIV, National Institute of Virology; PCR, Polymerase Chain Reaction; dsDNA, Double-Stranded Deoxyribonucleic Acid; EEV, External Enveloped Virion; IMV, Intracellular Mature Virion; EFC, Entrance Fusion Complex; VPS52; Vacuolar Protein Sorting-Associated Protein 52; VPS54, Vacuolar Protein Sorting-Associated Protein 54; TPOXX, Tecovirimat; FDA, Food and Drug Administration; VIGIV, Vaccinia Immune Globulin Intravenous; GO, Gene Ontology; KEGG, Kyoto Encyclopedia of Genes and Genomes; HMPS, Herbal Medicine Practitioners; COVID-19, Coronavirus disease-2019; EA-IND, Enhanced access to a new medication under research procedure

1. Introduction

The monkeypox virus, (MPV) is a double-stranded DNA virus that infects people and produces symptoms like muscle aches, fever, headache, and a characteristic rash that progresses to pustular lesions on the skin that closely resembles smallpox infection. The MPV, which is interconnected to the Variola, Cowpox, and Vaccinia, is a member of the orthopoxvirus genus having an oval-shaped structure and lipoprotein-encased outer membrane [1]. Smallpox and monkeypox are both caused by the same orthopoxvirus, thus getting vaccinated against smallpox three to five years before getting sick will protect you against MPV [2]. Similar to smallpox, in terms of clinical appearance, MPV causes a milder rash with a low fatality rate [3]. The virus can transfer from direct contact with an animal to a human through sores or body fluids. The MPV refers to the viruses that have been found to have primary carriers, such as rodents, although it was initially discovered in monkeys. Two distinct clades of the human metapneumovirus have been identified in: the Central African (CA) clade and the West African (WA) clade. The CA clade is associated with a mortality rate of 10% in non-vaccinated humans. On the other hand, the WA clade has been linked to a milder form of the disease, characterized by a lower mortality rate and fewer instances of human-to-human transmission [1].

The World Health Organization (WHO) has classified diseases associated with the Poivrade family as having the potential to escalate to epidemic or pandemic levels. Among these diseases is the MPV, which is linked to the Orthopoxviral genus [1]. This virus belongs to the Poxviridae family and the subfamily Chordopoxvirinae, within which the genus Orthopoxvirus encompasses several distinct viruses. Natural hosts consist of vertebrates, such as mammals, and arthropods. This genus has twelve different species and is linked to several diseases, including smallpox, cowpox, horsebox, and monkeypox [1]. The Central African clade is more dangerous and virulent, with a proliferative number of 0.6 to 1.0. While there are distinctions among the regions of the genus which produce virulence and have a host range [4].

2. Structure and genome

The MPV is oval and surrounded by an external lipoprotein membrane, similar to other poxviruses. The outer membrane protects the virus's DNA, along with its transcription factors and enzymes. Normal viral DNA replicates and expresses its genomes in the nuclei of eukaryotic cells. However, the protein stored in the genome of the MPV is what primarily allows them to reproduce in the cytoplasm. They mainly rely on the machinery of the host cell [5]. The 200 kb long genome of the MPV codes for around 200 different proteins. The 3' and 5' ends of its linear, double-stranded DNA are covalently closed at both ends. Each virion has a core that houses the DNA and the enzymes necessary for replication and the removal of the protein covering. Genes also involved in crucial processes like viral transcription and assembly are encoded in the viral genome's center, The feature of spike proteins, for example, are present in genes situated on the infectious genome's peripheral that are more likely to be involved in relationships between a virus and the host cell. With 190 distinct open reading frames, the MPV Genetic genome is around 197 kb in size [6]. A conserved coding with varied inverted terminal repeats is seen in the MPV. The DNA sequence between the start and stop codons is known as coding sequence or CDS. Monkeypox is a large virus in contrast to other viruses. As a result, it is more challenging for the infectious agent to bridge gap junctions and otherwise get past the host's defenses. The virus's enormous size makes it more difficult for it to proliferate quickly and escape an immune response [5]. By expressing internal as well as external modulatory proteins, monkeypox as well as different orthodox viruses are able to evade host immune responses and buy more time for proliferation. The MPV has multiple surface proteins that facilitate entrance into host cells and may connect with host

cells using 11–12 transmembrane proteins. On the cell surface, it most likely binds to laminin or glycosaminoglycans. It is less likely to alter since it is a DNA virus rather than an RNA virus like SARS-COV-2 [7].

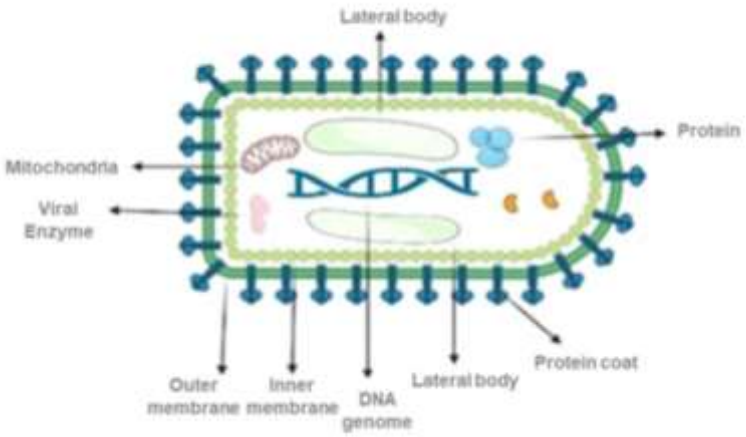


Figure 1. Cell Structure of Monkeypox virus

3. Occurrence and transmission

The World Health Organization has announced that, it will be using the term MPV in its communications and is urging everyone to take action based on these recommendations. The World Health Organization said in a statement released on November 18, 2022. Even if a person shows no symptoms, they might still get the MPV [8,9]. In the statement released on November 18, 2022, the World Health Organization said it will accept the phrase MPV as part of its communications and invited people to follow these recommendations. The disease can mimic chickenpox, measles, or smallpox but it can be distinguished by the erge before the rash in the neck, gone, behind the ear, or below the jaw. Many cases of the 2022 MPV outbreak also had a fever, swollen lymph nodes, vaginal and peri-anal lesions, and difficulty in swallowing. However, some patients only had a single sore where the disease was present [10]. More than two-thirds of those with lesions in the mouth, out of which 75%, have also found to have lesions on the genitalia, palms and soles. They begin as tiny flat spots, change into small bumps, filled with fluid (initially transparent fluid, then yellow fluid), rupture, and form a scab that lasts for around ten days. There might be a few lesions or hundreds, and sometimes smaller lesions might join together to generate bigger ones. After the healing of lesions, light traces may be left behind followed by development of dark scars [11].

Humans get infected by animals by biting or through wounds, cooking wild meat, or coming into contact with contaminated mammal fluids or lesion material. The body's breathing system, the eyes, nose, and mouth which contain the mucous membrane, and even skin cracks are thought to be ports of entry for viruses. Once infected, it is typical for the infection to spread to other people, with family members and medical personnel being at a higher risk than most [12]. Through breathing (airborne) contact, in contact with bodily fluids from affected individuals, or mother-to-fetus transmission during pregnancy, the virus can spread from one person to another. There are indications that the infectious monkeypox virus, which can be identified from samples of semen, can spread during sexual contact [13]. It can also be spread through microbes or by inhaling the lesion material, including contaminated bedding, even with personal protective measures. The most likely cause of transmission is inhalation [14].

4. Epidemiology and diagnosis

In various small towns of Basankusu, Equateur Province, Democratic Republic of the Congo (previously Zaire), the monkeypox virus was first linked to a human illness in 1970. Between 1981 and 1986, 338 verified instances and 33 fatalities in DRC/Zaire were recorded under WHO monitoring (CFR 9.8%). In the Democratic Republic of the Congo (DRC), 511 instances were reported between 1991 and 1999, and a second outbreak was found there in 1996–1997 [15]. In previous epidemics, the case death rate (CDR) varied from 3% to 6% by the end of May 2022, while the overall CDR of the current epidemic in 2022 remains below one percent. There had never been a case of human-to-human transmission before the 2022 European outbreak of MPV. Prairie dog owners in the Midwest of the US experienced their initial case of MPV not from Africa during the Clade II outbreak in 2003. 71 people reportedly developed the sickness, although none

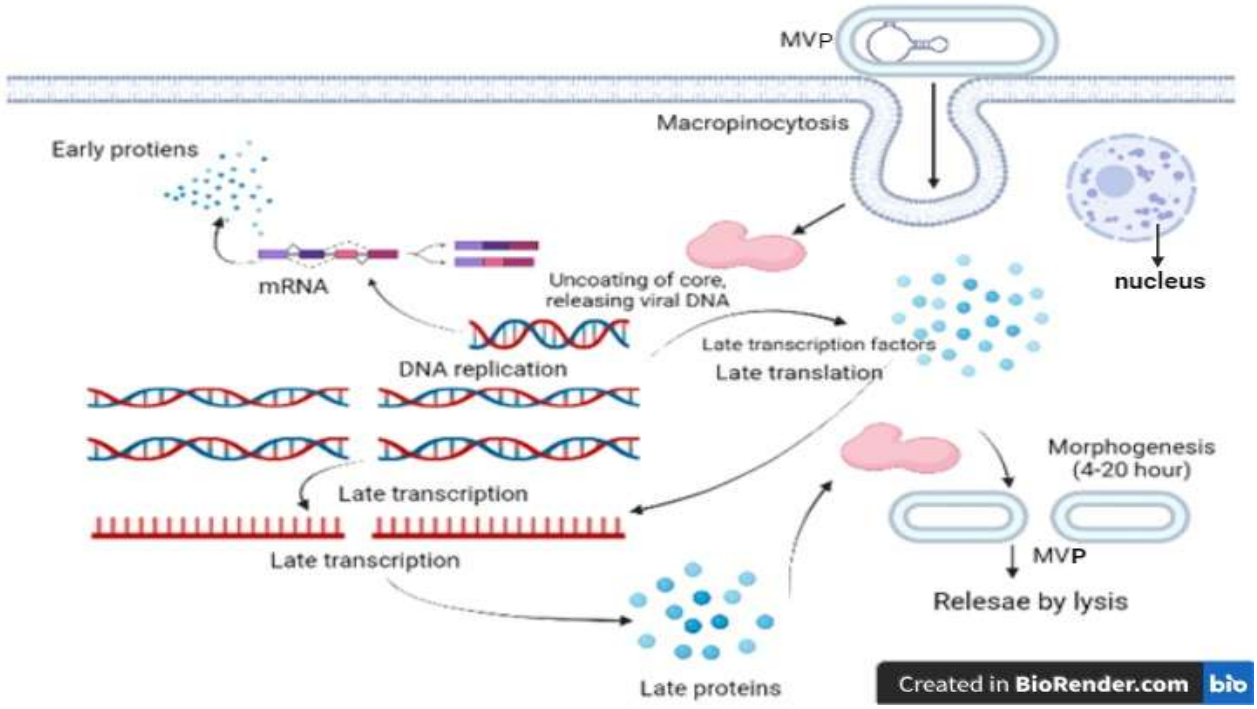
of them passed away, according to sources [16,17]. There have been a lot more MPV cases reported in Central and West Africa, mainly in the Democratic Republic of the Congo: there were, on average, 2000 cases per year between 2011 and 2014. The fact that the data collected is sometimes incomplete and unreliable makes it difficult to make realistic predictions about how many MPV cases will occur over time. However, it was claimed that since the start of 2018, both the cases of MPV reported and their distribution across the country has increased [15]. The West African lineage that carries the MPV is the cause of the ongoing human MPV breakout in 2022–2023 in India. The epidemic was discovered in India for the first time on the fourteenth of July in 2022, after Veena George, Kerala's state health minister, disclosed a suspected case that was confirmed by the National Institute of Virology (NIV) Alappuzha. India became the tenth nation overall and the first in South Asia to report a case of Mpox. The first local transmission case in Delhi was reported on July 24, 2023 [17].

The medical differential diagnosis must account for other rash conditions such as chickenpox, measles, skin infections caused by bacteria, scabies, and sexually transmitted sensitivities brought on by medicinal products. When the sickness is in its prodromal stage, lymphadenopathy allows Mpox to be separated from chickenpox or smallpox. The diagnosis can be confirmed by doing a viral test. The primary laboratory test for skin lesion samples is polymerase chain reaction (PCR) analysis. Given how little time the virus is present in blood, PCR blood testing is frequently inconclusive. Information on the date of the fever's commencement, the rash's onset, the collection of the specimen, the stage of the rash as it is at that time, and the patient's age are needed to interpret the test findings [9].

5. Pathogenesis

MPV has an oval, brick-like structure that is 200–250 nm in size. The Linear double-stranded DNA (dsDNA) found in viruses, which is approximately 197 kb in size, is contained in a dumbbell-shaped nucleus surrounded by lateral bodies [18]. Viruses have an outer layer made of lipoprotein with small tube-like structures on the surface. Their DNA strands are connected at the ends by palindromic hairpins. These hairpins are different from inverted terminal repeats, which also help to start DNA replication in DNA viruses. Inverted terminal repeats contain a loop, repeated sequences, and a few sections that can be translated into proteins. DNA replication starts at one end of the inverted terminal repeats and moves to the other end [19]. There are 190 mostly non-overlapping ORFs in the MPV genome, each with about 60 amino acid residues, similar to other Orthopoxviruses that have structural characteristics. Additionally, the MPV genome's core contains highly conserved genes that are shared by all orthopoxviruses. The Four left terminal ORFs are duplicated throughout substantial stretches of the right side of the MPV genome as part of the terminal inverted repeat. Due to ORF deletions and truncations, these terminal regions show significant variance. MPV and the Variola virus share around 84.5–84.6% of the nucleotide sequences of their genome [18].

The host cell containing cytoplasm has similar lifecycle of other orthopoxviruses and MPV. The virus enters the host cell by using its proteins (B5 and A34) to attach to glycosaminoglycan on the host cell's surface [20]. As a result, the cytoplasm containing the host cell releases the virion materials. In the subsequent phase, viral RNA-polymerase causes the uncoating of the whole viral genome after transcription of the early production of viral proteins, which can begin as soon as 30 minutes after infection [21]. Several genes that control viral DNA-polymerase recruitment for replication are expressed and occur during the following intermediate phase, which starts about 100 minutes after infection. Between two and eight hours after infection, the host cells Endoplasmic reticulum, and Golgi apparatus reticulum are activated, the host's cytoplasmic viral factories manufacture spherical proto-virions, and the transcription of late genes results in the production of structural proteins [21–23]. A mature virus can either blossom after gaining the Golgi apparatus's double membrane, the virion may either exit the host cell as an external enveloped virion (EEV) or it can be lysed out of the cell as an intracellular mature virion (IMV), which is not enveloped. The EEV further configures a microtubule in cell transportation that binds to the host cells lipoprotein [23,24]. Based on location, the Congo Basin and West Africa (CB and WA)) clades were identified phylogenetically based on disease severity and sequence homology, are two subgroups of MPV. It has been reported that the latter has been linked to a milder version of the disease. The CB clade has more severe human-to-human transmission, illness-related morbidity, death, and viremia. The most striking difference between the two clades can be attributed to the DNA sequence diversity for genes that are in the terminal area produce host-response modulation proteins [25–27]. This was revealed in previous epidemiological studies evaluating Mpox [27].



Figue 2. Pathogenesis of Monkeypox virus

6. The cycle and replication

As an Orthopoxviral, MPV only replicates in the cytoplasm of cells that it infects, where it builds factories out of the endoplasmic reticulum, which also serves as a site for the transcription and translation of viral mRNA [28]. MPV are able to attach to the cells outer layer with the help of viral proteins. A low-pH-required endocytic route is used by viruses to enter the host cells plasma membranes without the presence of a neutral pH. With the aid of its Entrance Fusion Complex (EFC), the monkeypox virus MPV may enter the host cell after attachment [29]. To translate mRNA into structural virions, the host ribosomes are used. Gene expression begins as a result of MPV releasing viral amino acids and enzymatic elements that leave the cell inactive. Even though mature virions can spread, they stay inside the cell until they are transferred from manufacturing processes to the Golgi/endosomal comportment. In order to contain the genomes of newly formed virions, currently referred to as extracellular viruses (EVs), protein production might break down the membrane of the factory [30,31]. Covering the virus and producing EVs need the VPS52 and VPS54 genes of the GARP complex, which are essential for transport. The virus needs EVs to spread across large distances and from cell to cell [31]. People can spread the infection from the time symptoms start until the time all lesions have crusted completely and dropped off, and evidence of dissemination may continue for up to a week beyond that [32,33]. This figure illustrates (Fig. 3) the monkeypox virus's life cycle within a human cell. Notably, the monkeypox virus replicates in the cytoplasm of the host cell. Once the virion fuses with the host cell membrane the cells cytoplasm releases the viral core. The generated viral particles can leave the damaged cell as extracellular wrapped viruses or remain within as intracellular mature viruses (MV). The virus can form a second outer layer, attach to the cell membrane, and exit the cell through exocytosis. Cidofovir and its precursor, Brincidofovir, block the virus's DNA polymerase, stopping it from replicating its DNA. Tecovirimat stops the virus from leaving an infected cell, preventing its spread. It does this by targeting the VP37 protein, which is necessary for the virus to get a membrane from the Golgi apparatus inside the cell. Clinical advice for live attenuated vaccines is being given for the prevention of monkeypox such as ACAM2000 and JYNNEOS, which were initially created to combat smallpox. Consequently, the vaccines developed, specifically for the prevention of monkeypox, is required. Such vaccines include vaccinations made of recombinant proteins, DNA, RNA, and inactivated vaccines. These immunisations have shown to be reliable and safe throughout the COVID-19 outbreak [32,33].

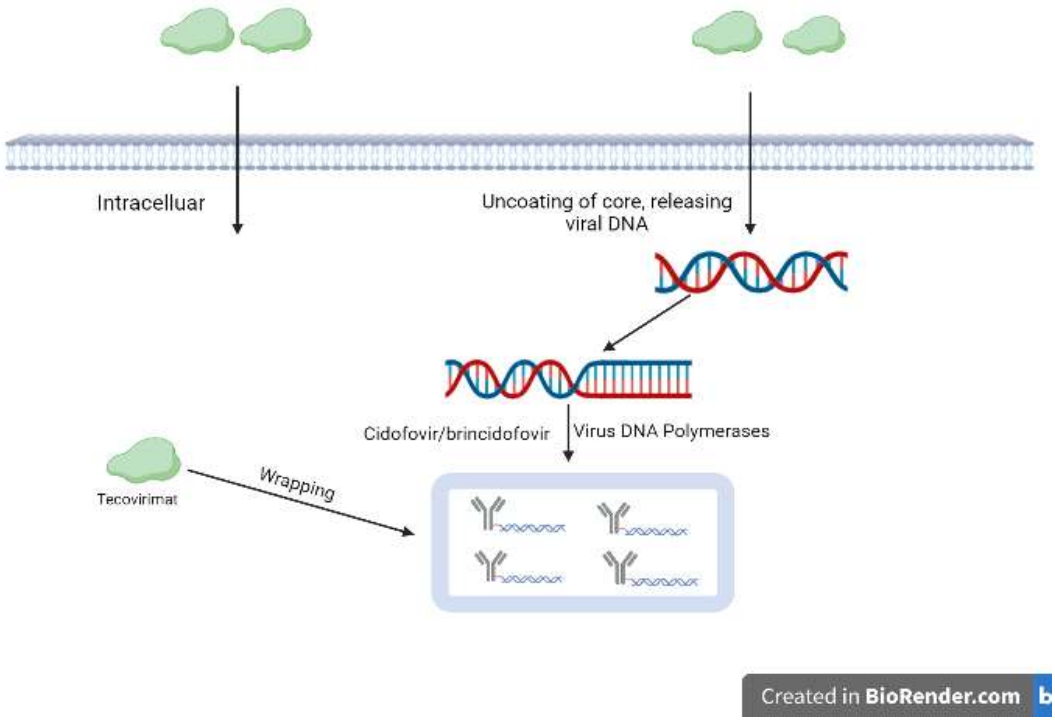


Figure 3. Virus multiplication in cell

7. Treatment

7.1 Allopathy

Tecovirimat: In 2018, the United States Food and Drug Administration (FDA or US-FDA) authorized Tecovirimat (TPOXX) to combat smallpox in both adults and kids. It prevents viral multiplication by inhibiting the viral envelope-wrapping protein VP37. It is presently free to use in the United States under enhanced access to a new medication under research procedure (EA-IND). Both oral and intravenous versions of Tecovirimat are offered, although there are no efficacy studies available. A study on TPOXX's effectiveness against monkeypox-positive security profile has been described with typical side symptoms including headache, nausea, vomiting, and abdominal discomfort. Additionally, the usage of neutropenia with one study participant was documented [32]. The use of intravenous formulation may cause erythema, discomfort, and swelling at the infusion site. Thornhill *et al.* discussed recent examples of Mpox treated with TPOXX [34]. Adler *et al.* successfully employed TPOXX to treat human Mpox [32]. Another case of Mpox treatment TPOXX was recently reported in Nigerian travelers returning to the US [35].

Brincidofovir: In June 2021, the FDA approved brincidofovir for treating smallpox in adults and children. Brincidofovir is a prodrug of cidofovir, meaning it changes into cidofovir and then into cidofovir diphosphate (CDP) inside cells. The active form, CDP, binds to viral DNA and stops the viral DNA polymerase and prevents the virus from replication (Fig. 4). There are not many extensive human studies on the efficacy of Brincidofovir and MPV, however, an animal model demonstrated protection from deadly Mpox, with rates of survival of diseased prairie dogs ranging from 29 to 57%, depending on when therapy was started [36]. Adler *et al.* and others recorded three instances of treatment of human monkeypox with brincidofovir. The rise of liver enzymes led to the termination of treatment. Brincidofovir has a better renal safety profile and is accessible as a pill and an oral suspension [32].

Cidofovir: Cidofovir, the prodrug of brincidofovir, works the same way as brincidofovir. There is not much considerable research on humans on cidofovir's effectiveness against MPV Animal studies on its effectiveness to combat orthopox viruses such as Ectromelia, Vaccinia, Rabbitpox, and Cowpox is known [37]. Only an intravenous preparation is available, and it can be seriously toxic to the kidneys [34].

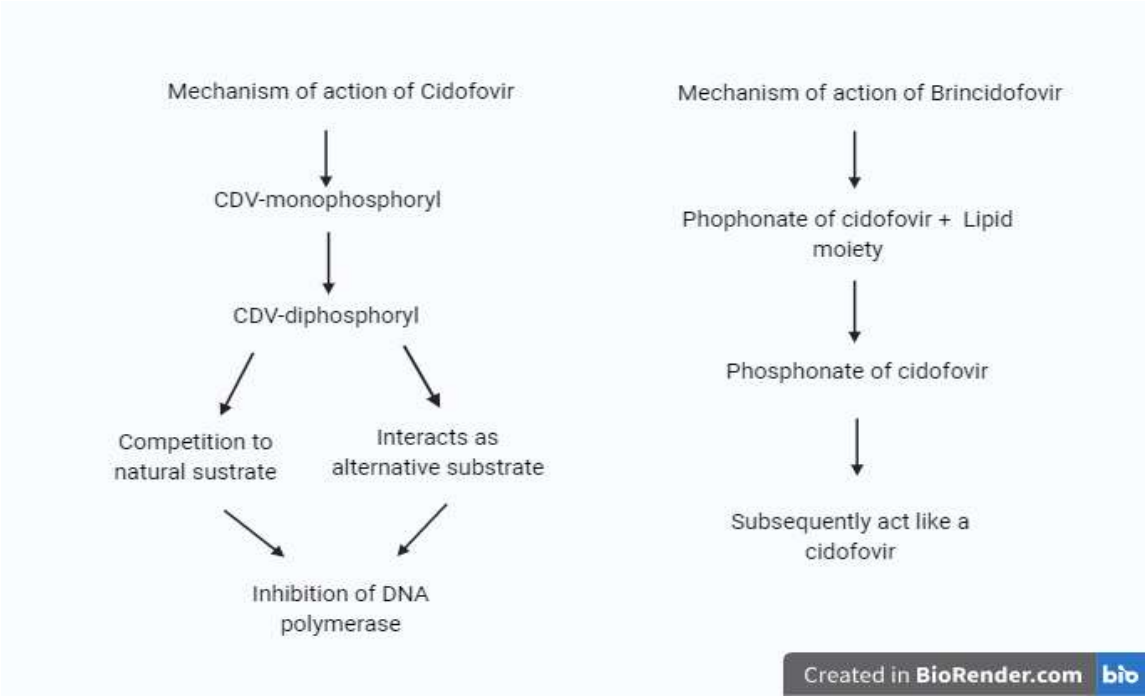


Figure 4. Mechanism of action of Brincidofovir, Cidofovir

7.2. Vaccines

Vaccinia Immune Globulin Intravenous (VIGIV): The Vaccinia virus's aberrant infections, eczema vaccinatum, and vaccinia (progressive or severe generalized) are among the consequences following immunization for which VIGIV has FDA-issued licenses. Additionally, it has applications to treat human vaccinia infections with specific skin problems. Although there is little data on its effectiveness against Mpox, it is nevertheless accessible as a reaction in the United States option in the case of outbreaks of the orthopedic virus under an EA-IND [38]. The US- Center for Disease Control and Prevention (CDC) has issued preliminary instructions for treating Mpox. Antiviral treatment has been advocated for those with severe illness, comorbidities, aberrant disease in unusual places, and high risk for severe illness. Age under 8 years, exfoliative dermatitis of any kind, pregnancy, breast feeding, and immunocompromised state are risk factors for severe illness. Uncontrolled Human Immunodeficiency Virus, Arterial Input Function, iatrogenic immunosuppression brought on by the use of antimetabolites and alkylating agents, and tumor necrosis component alpha; leukemia; lymphoma; other cancers; Hematopoietic stem cell transplantation, radiotherapy, and solid organ transplantation within 24 months of transplant or more than 24 months after illness recurrence or transplantation with graft-versus-host disease; autoimmune condition with immunodeficiency; and along with good pain treatment, symptomatic and also include crucial supportive services [39,40].

ACAM2000: First-generation vaccinations against vaccinia, can offer about 85% protections against Mpox infection. In August 2007, the USA licensed the live attenuated vaccinia vaccine ACAM2000. For the protection of smallpox, second-generation vaccines were used [41,42]. Its efficiency was evaluated by using animal models and human clinical trials [43–45]. A single dose of ACAM2000 which was received by cynomolgus macaques showed its resistance to aerosolize MPV [43]. All (n =12) of the monkeys that were exposed to the lethal Monkeypox virus survived after being immunized with the live attenuated smallpox vaccine ACAM2000 [45]. In a prairie dog model, ACAM2000 immunization, one day after exposure was just as effective as it was administered three days after exposure, leading to 50–62% survival as opposed to 25% of people in the unprotected group [44]. ACAM2000 is most probably successful in preventing Mpox when administered in combination, but due to its propensity for sexual reproduction, it might also have harmful side effects such as myopericarditis, eczema vaccinates, and progressive vaccinia [46–54]. It is not advised for use by anyone with compromised immune systems, including those who are HIV-positive ladies who are pregnant and those who have skin diseases like eczema [52].

JYNNEOS: The DNA vaccine, modified vaccinia Ankara in the United States, European Union, and Canada, IMVANEX and IMMUNE respectively, were authorized in 2018 to minimize the risk of Mpox and smallpox illness. Individuals aged 18 and up are thought to be more vulnerable to smallpox or Mpox. JYNNEOS, in contrast to ACAM2000, is a nonreplicating vaccine that inhibits the generation of live viruses. In animal models and clinical studies, JYNNEOS has

shown high immunogenicity, safety, and effectiveness as a smallpox vaccine [55–68]. It was the only vaccinia vaccination currently licensed by the FDA for the prevention of Mpox illness. Numerous studies using animal models revealed effective anti-Mpox defenses [47,68–70]. Additionally, in trials involving macaques, total immunity was demonstrated as long-term immunity against Mpox infection and long-lasting immune protection against a deadly challenge with Mpox [71–73]. The effectiveness and security of JYNNEOS have been proved in many clinical trials using MVA [74-76].

7.3. Traditional medicine - A compliment to Monkeypox care

The traditional, complementary, and alternative systems of medicine have historically been effective in treating a wide range of microbial infections. These systems take a holistic approach, drawing from rich cultural heritage and providing accessible, affordable, and sustainable treatments with proven pharmacological effects [77]. All over the globe, numerous systems such as Traditional Chinese Medicine (TCM), Kampo (Japanese Traditional Medicine) [78], Ayurveda, Yoga, Naturopathy, Unani, Siddha and Homoeopathy, Native American Medicine, Bush Medicine, etc. have been regulating the health of common people. Additionally, herbal remedies, which have been utilized for centuries, are valued for their safety, efficacy, cultural acceptance, and tendency to produce fewer adverse effects when contrasted with allopathic medications. Moreover, the treatment of viral infections has incorporated a variety of traditional medicinal practices from diverse cultures. For instance, in the Indian system of medicine, AYUSH 64, Ayurveda *Rasayana, and Triphala* are known for their antiviral properties. Similarly, Japanese Traditional Medicine has contributed *Juzentaihoto, Hochuekkito, and Shoseiryuto* as potential treatments for viral infections. Additionally, Native American Medicine has utilized the decoction of *Cornus canadensis* L in the modulation of immune response [79–81].

A study carried out by Jiao *et al*, [82], an in-depth investigation was conducted to navigate the role of TCM in the context of Mpox infection. The study aimed to comprehensively evaluate the immunomodulatory and antiviral properties of *Xuanbai chengqi* (XBCQD) decoction and their potential application in managing and treating Mpox infection. Before its exploration against Mpox, it was found to be a supplementary measure for Severe Acute Respiratory Syndrome Coronavirus 2. In China, people widely use XBCQD to get relief from chronic lung diseases. In June 2023, to control the spread of Mpox, The National Administration of Traditional Chinese Medicine and China National Health Commission collectively issued guidelines recommending XBCQD to treat people who suffered with monkeypox-related symptoms. They conducted a comprehensive evaluation of XBCQD decoction and investigated the molecular mechanism in treating Mpox infection. Emphasizing the importance of computational analysis i.e., molecular dynamics simulation, network pharmacology, and other docking tools many molecules have been identified effective against different viral strains. Based on the literature data, beta-sitosterol, phytol, estrone, gamma-aminobutyric acid, and stigmasterol are active compounds, and MYC, JUN, TP53, CCNB1, ESR1, CASP3, 1L1B, AR, CDKN1A, TNF were huge targets selected for the study. Results suggested that the therapeutic effect of XBCQD decoction in MPOX is regulated through signaling pathways concerning viral manifestation and inflammatory response. Among the top five compounds, Estrone has efficient binding to target the Androgen receptor (AR) and concluded that it could be a choice for Mpox. The overall conclusion was that the study provided a robust scientific base for further pharmacological exploration.

Another computational study was performed with the objective of extracting Wan Quans expertise in the treatment of smallpox, as documented in the exclusive method for treating pox, to acquire the most involved prescriptions, combinations of herbs, and components for complementary Mpox therapy. For this, 119 were selected from the exclusive method for treating pox, and among them, 25 were more time-used prescriptions, along with these 19 pairs of prescriptions were also prepared many times. In a study on combined association rule mining analysis, *Gancao, Shengma, Danggui, and Zicao* were identified as the primary Chinese medicine pairs for further evaluations. Using systematic network pharmacology, researchers found 131 active components and 348 candidate targets associated with these core Chinese medicine pairs. Molecular docking data showed that *Celabenzine* and *Quercetin* had strong binding affinities. Furthermore, GO and KEGG enrichment analyses suggested that these major Chinese medicine pairs may interact with targets related to infectious diseases, immune regulation, and inflammation pathways, potentially offering relief from viral symptoms. The results from virtual screening are important despite its practical limitations. So, to explore obtained computational results in detail, Preclinical studies must be needed at the latter stage. However, it could be enough foundation for the development of potential antiviral natural products [83].

Ayurveda has techniques from ancient times that have a beneficial impact on health and some of them which can be utilized to evaluate Mpox includes *Shadvidha, Ashtavidha, Dwadasha, Dashavidha Parikshya Bhava.* [84] Additionally, one article was demonstrated on the website of Planate Ayurveda, discussing the Ayurvedic remedies that can be used in the management of Mpox infection, which highlighted the importance of purification of vitiated dosha along with

termination of microorganism produced toxin from blood. Furthermore, Giloy decoction is very beneficial for treating the MPV since it boosts immunity and lowers fever. Before consuming the tea, added leaves of Tulsi acted synergistically and lowered the fever and worked as a preventative. Turmeric milk also helps to immunize the patients. Thus, the use of the above herbs as mentioned in Ayurveda can prove beneficial in treating viral infections including Mpox. Along with this, Planate Ayurveda [85] has manufactured herbal products that can help to manage the ongoing spread of Mpox infection. The product name, description, and doses are represented in table 1.

Table 1. List of Ayurvedic products proposed to be used against Mpox.

Sr. no	Product name	Product description	Properties	Dose and direction
1	*Curcumin Capsule*	Standardized extract of *Curcuma Longa*	Anti-inflammatory, analgesic, antibacterial, and antiseptic	One capsule once a day following a meal
2	*Septrin Tablets*	*Commiphora mukul, Curcuma longa, Piper longum, Zingiber officinale, Piper nigrum, Ocimum sanctum*	Analgesic and antipyretic	One tablet twice per day post-meals
3	*Maha Sudarshan kwat*	*Terminalia chebula, Emblica officinalis, Terminalia billerica, Curcuma longa, Curcuma eodaria, Zingiber officinale, Pippali Piper longum, Tinospora cordifolia, Picrorhiza kurroa, Fumaria parviflora), Valeriana wallichii, Trachyspermum ammi, Acorus calamus, Bambusa arundinacea*	Immunomodulatory and antipyretic	Two teaspoons daily after a meal
4	*Ghandak Rasayan*	Shuddha gandhak	Antiviral, anti-inflammatory, and anti-rash abilities	One tablet two times a day with lukewarm water following meals

As the number of Mpox cases raised in the African region, especially in northern Nigeria, there was a heightened focus on traditional herbal medicine in addressing viral diseases. Consequently, a study was conducted to examine the application of traditional practices and plants in addressing emerging and re-emerging viral diseases. These diseases included COVID-19, Monkeypox, Hepatitis, Poliomyelitis, Smallpox, Yellow Fever, and Meningitis, within the regions of Africa. To explore, enough data was collected through questionnaires and oral interviews with herbal medicine practitioners (HMPs) regarding the medicinal plants used, preparation methods, and treatment approaches. The plants gathered during the study were carefully identified using botanical methods and cross-referenced with online resources, the data accuracy in the research was meticulously upheld through thorough verification using World Flora, and the International Plant Names Index. Remarkably, out of the 280 herbal medicine practitioners who participated in the study, comprehensive documentation of 131 plants from 65 families was achieved, with 46 of these specifically linked to the treatment of Mpox. The diverse utilization of plant parts, such as roots, bark, leaves, seeds, and fruits, in various preparations including decoctions, infusions, and ointments for both oral and topical use, reflected the extensive knowledge and practices of the practitioners. Noteworthy mentions of plants like *Moringa oleifera, Elaeis guineensis* Jacq., and *Acacia nilotica* in the regions of *Kebbi, Kwara, and Sokoto* respectively highlighted the regional diversity and significance of herbal medicine practices. This study highlighted the potential of largely uninvestigated medicinal plants in treating viral diseases and underscores the need for future research to assess their antiviral efficacy and isolate novel bioactive compounds. In summary, traditionally used medicinal plants are listed (Figure 5) from different locations of Northern Nigeria [86].

Figure 5. Medicinal plants used in treatment of Mpox and related viral diseases in Northen Nigerian region.

8. Conclusion

The recent studies aimed to give an outline of the monkeypox virus, including its genetic complexity and pathogenesis. It has a double-stranded DNA virus similar to other poxviruses such as Vaccinia, Variola, and Cowpox. The studies also provided details about the size and composition of the viral DNA and the characteristics of its nucleus and highlighted how the virus hijacks the human cell machinery for replication. Additionally, the studies summarized the current allopathy and immunization-based therapeutics and offered deep insights into the potential of traditional systems of medicine for the control, systematic management, and treatment of monkeypox infection.

9. Future scope

Based on the provided information, the future scope regarding Monkeypox could involve the following areas such as: (1) Research into novel preventive measures such as vaccinations and post-exposure prophylaxis. (2) Study of the epidemiology and transmission dynamics, especially in high-risk populations such as healthcare workers and individuals with close contact with infected individuals. (3) Development of effective treatment strategies, including exploring traditional or alternative medicine, such as Traditional Chinese Medicine, Ayurvedic treatments etc. to complement existing medical interventions. (4) Investigation into the potential for zoonotic transmission and strategies to prevent spillover events from wildlife to human populations.

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