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Spotlight on Fowl Adenovirus (FAdV): History, Classification, Pathogenicity, Diagnosis, and Control

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Review Article

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Abstract

Fowl adenoviruses (FAdVs) are recognized as critical viral pathogens in the poultry industry, associated with severe economic impacts worldwide. FAdV is a non-enveloped dsDNA, which belong to Adenoviridae family. FAdVs cause a range of diseases in chickens, including inclusion body hepatitis (IBH), hydropericardium hepatitis syndrome (HHS), and adenoviral gizzard erosion (AGE). FAdVs are classified into five different species (FAdV-A to FAdV-E) due to their molecular structure, and also into 12 serotypes (FAdV-1 to -8a and 8b to -11). FAdVs are transmitted vertically and horizontally, horizontal transmission was documented by oral-fecal route (lateral), in addition to fomites or Airborne infection. The mechanical spread of FAdVs by wild birds have been mentioned in relation to disease transmission. FAdV infections in chickens have undergone significant changes in recent decades, influenced by both host and pathogen factors. These changes may result from the evolution of viral strains, alterations in poultry management practices, environmental factors, and genetic diversity within chicken populations. As a result, the nature and impact of these infections have shifted, requiring the development of updated strategies for their control and prevention. Therefore, this review article deals with the FAdVs history, classification, pathogenicity, diagnosis as well as different methods of prevention and control.

Keywords: *Fowl adenoviruses, transmission, Classification.*

Historical overview:

Since the identification of FAdVs in 1949, they have been recognized for decades as major viral pathogens in the poultry industry, owing to their widespread presence and the significant economic impacts they cause worldwide. The first case was recognized in a bovine type from a case of nodular dermatitis **(Van and Don 1949)** subsequently, numerous strains of chicken embryo lethal orphan (CELO) virus were identified from chicken embryos **(Yates and Fry 1957)** and gallus adeno-like (GAL) virus was obtained from chicken cell culture **(Burmester *et al*., 1960).** In 1952, Olson formally isolated fowl adenovirus named quail bronchitis virus (QBV) from North American quail with bronchitis **Olson (1951).** Since the first report of FAdVs, the disease has become prevalent in many countries worldwide and has markedly affected the global poultry industry **Guan *et al*. (2018).**

History of Fowl Adenovirus in Egypt

In Egypt the first report of fowl adenovirus 8a from commercial broiler chickens in Behira province during 2015 **Radwan *et al*. (2019).**

Also, in Kafr El Sheikh **El-Tholoth and Abou ElAzm (2019)** distinguished FAdV type D in Egypt during 2017-2018 **Elbestawy *et al.* (2020)** verified the presence of type D of the virus by molecular techniques in broiler accompanying by the presence of inclusion body hepatitis **Lebdah *et al.* (2022)** were isolate and molecularly characterized 8a serotype from commercial broiler chickens in Sharkia province during 2019 to 2020. The first case of FAdV-4 in Egypt reported by **Sultan *et al.* (2021),** who isolated it from broiler flock at 32 day of age in Alexandria**. Adel *et al.* (2021)** detected the emergence of new FAdV serotypes 1, 3, and 8b in Egypt for the first time.
The recorded FAdV in Egypt highlight the need to routinely check one day old chicks by PCR technique to confirm free from FAdV vertical transmission and the need to focus on the current vaccination regimes of the breeder flocks to decrease breeder hens susceptibility to infection and decrease risk for vertical transmition of diseases to their progeny, in addition to reduce the early age infection of chicks when the breeder hens transfer enough maternal antibodies to protect their progeny in early age.Further studies are required to complete molecular characterization of circulated FAdV to study their genetic diversity and relatedness to the current used vaccines and using updated, potent, effective vaccines from locally isolated strains. Also further investigations are required on the epidemiology of FAdVs in Egypt, the pathogenicity of the isolated viruses and the potential association with other pathogens and managemental factors that may enhance their virulenc.

Classification of FAdV

Fowl adenovirus (Aviadeno virus genus) is a non-enveloped dsDNA related to Adenoviridae family **Adair and Smyth (2008).** The FADV viral genome has various sizes extending from 43 to 45 kb, and the virus is encoding about ten structural proteins and many non-structural proteins **Griffin and Nagy (2011), Nagy *et al.* (2019)**.
The structure for the virus is major capsid proteins, and is recently investigated by **San Martin (2012),** that includeing Hexon, fiberes and pentose base
The genus Aviadeno virus includes group 1 avian adenovirus **Smyth and McNulty (2008),** which are isolated from poultry and classified into 5 different species (A-E), represented by 12 types FAdV-1-8a and FAdV-8b -11 **Hess (2013); Fitzgerald *et al.* (2020).** Fowl adenovirus of group 1 in chickens can cause important diseases in chickens such as inclusion body hepatitis (IBH), hepatitis hydropericardium syndrome (HHS), and adenoviral gizzard erosion (AGE) **Niu *et al.* (2018); Schachner *et al.* (2018).**
Swollen hemorrhagic liver and Appearance of Inclusion Body in hepatocytes (IBH) are the most characterized features of different types of adenoviruses like type 11/D, 2/D, 8a/E and 8b/E. **Adair and McFerran (2008); Hess (2013); Zhao *et al.* (2016).** IBH is most commonly detected in broilers chicks aged 2–20 weeks **Hafez (2011); Sahindokuyucu *et al.* (2020).**

Pathogenicity of FAdV

adeno viruses are quickly transferred among flocks **Cowen (1992),** the vertical transmission of the virus from parent to chicks through eggs was reported **Hess (2012).** Therefore different mechanisms of infection transmission were documented and discussed in **1967 by Du Bose,** resembling oral-fecal route (lateral), in addition to fomites or Airborne infection is a potential means of transmission. Likewise, the spread of FAdVs mechanically by wild birds have been mentioned in disease transmission, adding to Experimental trials have been succeeded for disease induction by **Asrani *et al.* (1997)** as they inoculate FAdVs liver homogenate by subcutaneous route inoculation**.** Nevertheless, oral induction of the disease was also demonstrated **Naeem *et al.* (2001).**
FAdV has been isolated from apparently healthy flocks and flocks suffering from different clinical signs that varied from respiratory signs to depressed egg production, arthritis/ tenosynovitis, uneven growth or even enteritis with different mortality rates **Adair and McFerran (2008).** FAdVs are transmitted vertically and horizontally, the highest titres are found in faeces **Gomis *et al.* (2006).**
The mortality and severity of FAdV infections can be influenced by various factors, including

degree of virus pathogenicity, chicken breed **Schachner *et al*. (2018),** the immune status of the birds and concurrent infection with other immunosuppressive infectious agents **Toro *et al*. (2000); Grgic *et al*. (2011).**

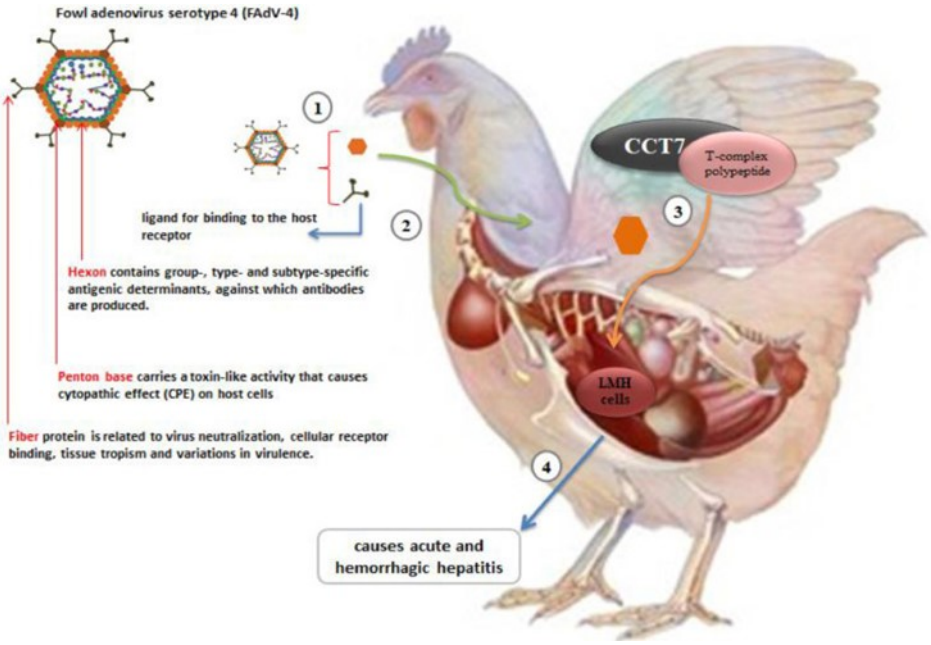
The broilers can be infected by many types and species of inclusion body hepatisits as type D and E (serotype 2, 3, 6, 7, 8a, 8b, 9 and 11). sudden onset of mortality that reach 5% to 10% may appear at younger age about one week of age and the main picture is the presence of swollen liver and heemorrages with IBH **Adair and McFerran (2008); Hess (2013).** The pronounced deviation in the mortality rate associated with FAdV is as the stage of virus pathogenicity, concurrent infections and host susceptibility **Grgic *et al*. (2011).**

FAdV-4 (species C), have serious role in the etiology of hydropericardium syndrome, leads to high mortality that varies from 20% to 80% **Asthana *et al*. (2013).** There were many types of FAdV-1 strains as type A can cause inflammatory erosive gizzard and appearance of growth retardation, other types cause serious liver damages and resulting in appearance of a situationof inclusion body hepatitis **(IBH).** The immunosuppressive potential of FAdV, causing reduced humoral and cell mediated immune response to other antigens and vaccines, has been well documented **Schonewille *et al*. (2008).**

FAdV may be a possible primary pathogen especially in broilers exacerbating other diseases **Morshed *et al.* (2017)**, co-infection of FAdV and other immunosuppressive pathogens was previously reported which increase morbidity and pathogenicity of other diseases **McFerran and Smyth (2000).** FAdVs has potential immunosuppressive ability due to reducing humoral and cell-mediated immunity, for example serotype 8, was found to induce depletion in the lymphoid organs, including the bursa, spleen, and thymus, leading to a reduction in antibody production which can increase the susceptibility of infected birds to other pathogens and their ability to worsen the severity of other infections, even though the existence of vaccination and treatment **Schonewille *et al.* (2008); Singh *et al.* (2006); Radwan *et al.* (2019).**

Roles of the Major Viral Proteins of FAdV in the viral Pathogenesis

FAdV-4 genome enclose numbers of open reading frames (ORFs) reach 46,ten structural proteins and about 32 non-structural proteins. The major structural proteins consist of hexon, penton base, fiber (fiber-1, fiber-2), terminal protein, and proteins V, VI, VII, VIII, IIIa, and X **Li PH *et al*. (2017),** while non-structural proteins include U exon, DBP, 52K, 100K, 22K, pIVaII, pol, 33K and so on **Nagy *et al*. (2019).** Attached to the DNA genome are terminal protein, proteins X, V, and VII within the virus particles **Nemerow *et al*. (2009)**. The study in china discussed the genomic deletion that was found in different and highly virulent strain type (FAdV-4) therefore the most detectable site was at 1966 bp at the right end region of the genome **Mo *et al*. (2019)**. Also, the virulence of strain FAdV-4 was recognized as self-regulating as the presence of 1966-bp deletion **Zhang *et al*. (2018); Pouladi *et al*. (2024)**, significant evolutionary studies have been prepared for explaining the role of different proteins present in the the pathogenesis of FAdV infection which still indistinct like fibers, protein of 100K and PX, hexon, penosesuger base.



Roles of viral proteins in the pathogenesis of FAdV

Diagnosis of fowl adenoviruses

The infections by FAdVs can be diagnosed by many ways; recently different types of molecular techniques are used for virus detection beside traditional methods.

1-Virus isolation as the virus propagated in the yolk sac or chorio-allantoic membrane of embryonated chicken eggs (ECEs) along with duck eggs, some signs appeared in the ECEs showing stunted growth, hemorrhages, curling and deaths, besides the existence of inclusion bodies **Toro *et al*. (2001).**

2-Molecular detection of FAdVs using polymerase chain reaction (PCR) technique is mainly depending on the detection of hexon gene loop 1 gene (Hex L1) which is a major capsid protein gene **Mase *et al*. (2009).** adding, detection of 52 K gene or sequencing of DNA-dependent polymerase gene are two modern methods used for recognition of the FAdVs **Kajan *et al*. (2013).**

3-Serotyping is done by detection of serotype-specific neutralizing epitope of FAdVs.

Grouping of FAdVs is done by using Restriction Fragment Length Polymorphism (RFLP) and resulted in five diverse species (A-E) using of digestive enzyme named HpaI for digestion process of PCR product **Raue and Hess (1998).**

4-Serological diagnosis by detection of antibodies against FAdVs has been applied using some serological tests like agar gel precipitation test, enzyme-linked immunosorbent assay **Manzoor and Hussain (2003).** But, using this serological tests may not accurate due to the presence of antibodies in both healthy and diseased birds **Thakor *et al*. (2012).**

Prevention and control of FAdVs:

FAdVs have many characteristics that help them to be of long survival in the environment and resist the inactivation processes, making the viruses easily persistent and transmissible both horizontally and vertically. the difficulty of control of the disease may come as a result of the concurrency of of other highly pathogenic viruses with FAdVs, like avian leukosis virus (ALV) with different subtypes, chicken anemia virus (CAV) infectious and bursal disease virus (IBDV). Application of biosecurity measure inside the poultry farms and application of Good management practices are very significant for prevention and control of all infectious diseases. Hence, it is recommended to use a good program for vaccination against FAdV. Some vaccines of other disease as HHS

have been proven to be active for controlling FAdV infection, and applied in many forms as attenuated live vaccines, Inactivated vaccines or recombinant vaccines **Areayi *et al*. (2021).**

Vaccination against (FAdV)

Commercial vaccines for controlling the infection by FAdV are still limited. However, the development of autogenous vaccines has been tried with variable degree of successfulness especially during outbreaks of IBH and HHS in many countries, Lately, application of vaccine by different ways like live attenuated, or inactivated vaccine was practically used in different countries to minimize the losses moreover new subunit vaccine, virus-like units, and autogenous products. Inactivated and live vaccines are used in some countries where FAdVs are endemic and outbreaks of the disease are frequent **Schachner *et al*. (2018).**

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