Introduction

Adenoviruses are common infectious agents in poultry and wild birds worldwide. Infection could be:

- In apparent
- Opportunistic
- Primary infection

- Economic Importance:
  - Mortalities, drop in egg production, complicating other affection through their latency, immunosuppression, contamination of live vaccines.

Adenovirus infection in poultry

Cont.

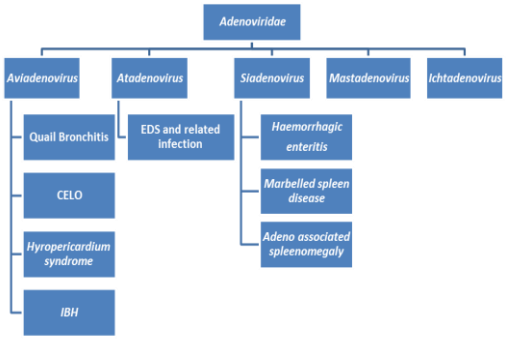
- **Antigenically:** Adenovirus hexon is the major capsid protein and contains type, group, and subgroup (serotype) specific antigenic determinants.
- 12 fowl serotypes have been recognized but there are many not yet classified.
- **Differences between serotypes:** Serum neutralization (SN), Hemagglutination inhibition (HI) (FAdv-1 and EDS), PCR.

Etiology

- Nucleic Acid: ds DNA
- Capsid: Icosahedral
- Envelope: Non enveloped
- Replication: Nucleus (intranuclear inclusions)
- Release: Cell lysis

- **Resist lipid solvents** (ether and chloroform, sodium deoxycholate, trypsin, 2% phenol, and 50% Alcohol) and variations in pH (3 and 9).
- Easily inactivated by **formaldehyde**, **glutaraldehyde** and **heat** (56°C for 30 minutes).

Classification



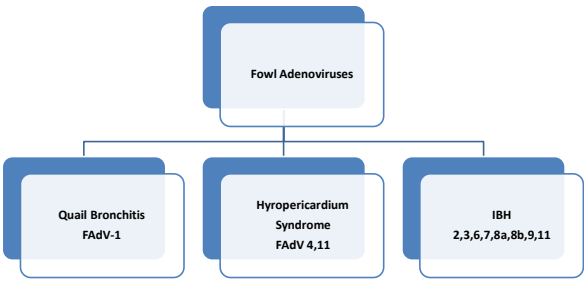
Hemagglutination

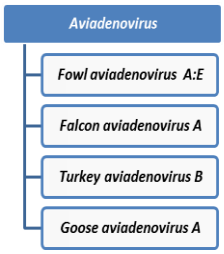
- ***Aviadenovirus serotype-1 (FAdV-1)***

– Hemagglutinates **rat** erythrocytes
– The hemagglutinin is **stable** to treatment with trypsin, RNase, DNase, and neuraminidase
– **inactivated after 15 minutes at 56°C.**

- ***Atadenovrus (EDSV)***

– Agglutinates erythrocytes of **chickens, ducks, turkeys, geese, pigeons and peacocks.**
– **Doesn't agglutinate rat, rabbit, horse, sheep, cattle, goat or pig erythrocytes.**
– The hemagglutinin (HA) is resistant to heating at 56°C. The HA also survived heating at 60°C but was destroyed by heating to 70°C for 30 minutes.





Genus Aviadenovirus
Fowl adenovirus *A*
Serotypes: Fowl adenovirus 1 (FAdV-1) (CELO, 112, QBV, Ote, H1)
Fowl adenovirus *B*
Serotypes: Fowl adenovirus 5 (FAdV-5) (340, TR-22, Tipton, M2)
Fowl adenovirus *C*
Serotypes: Fowl adenovirus 4 (FAdV-4) (506, J2, KR5, H2, K31, 61)
Fowl adenovirus 10 (FAdV-10) (C-28, M11, CFA20, SA2)
Fowl adenovirus *D*
Serotypes: Fowl adenovirus 2 (FAdV-2) (GAL-1, 685, SR48, H3, P7)
Fowl adenovirus 3 (FAdV-3) (SR-49, 75, H5)
Fowl adenovirus 9 (FAdV-9) (A2, 90, CFA19)
Fowl adenovirus 11 (FAdV-11) (380, UF71)
Fowl adenovirus *E*
Serotypes: Fowl adenovirus 6 (FAdV-6) (CR-119, 168)
Fowl adenovirus 7 (FAdV-7) (YR36, X-11, 122)
Fowl adenovirus 8a (FAdV-8a) (58, TR-59, T-8, CFA40)
Fowl adenovirus 8b (FAdV-8b) (764, B3, VRI-33)
Turkey adenovirus B (Turkey adenovirus 1, 2)
Falcon adenovirus A
Goose adenovirus A

Genus Atadenovirus
Duck adenovirus A (Duck adenovirus 1, egg drop syndrome)

Genus Siadenovirus
Turkey adenovirus A (Turkey adenovirus 3, TAdV-3)
Raptor adenovirus A
Great tit adenovirus A

Cont.

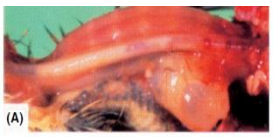
- Viruses are excreted from week 3 onward.
  - In broilers, peak excretion occurs between 4 and 6 weeks of age.
  - In layer flocks: two waves of virus excretion;
    - first wave peaks at 5-9 weeks following infection and can continue for 14 weeks post infection (in 70% of infected birds).
    - second wave of shedding occurs around peak of egg production (32 wks of age) due to the stress associated with egg production with egg transmission to the next generation.
- no cross immunity between serotypes within this group.

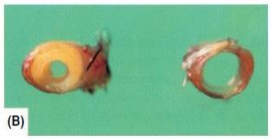
Epizootiology

- Adenoviruses are common in poultry and wild birds
- Persist in a contaminated environment.
- Vertical transmission is important
- Adenovirus infections can remain latent and undetected for at least one generation in SPF flock.
  - Most of the viruses replicate in healthy birds with little or no signs.
  - Coinfection with IBDV or CIAV enhances the pathogenicity of some avian adenoviruses.
  - Some AVs are primary pathogens e.g., TRT,QB, EDS.

Lesions

- **Excess mucus with thickening** and roughening of the mucosa of trachea and bronchi.
- **Air sacs may be mildly thickened and cloudy**.
- **Clouding of corneas,** conjunctivitis
- Mucosal congestion in the nasal passages and infraorbital sinuses are occasionally noted.





Quail Bronchitis (QB)

- **Acute, contagious and sometimes highly lethal respiratory disease of bobwhite quail** (Colinus virginianus) caused by an FAdV-1 (Aviadenoviruses - Fowl adenovirus A) and characterized by catarrhal tracheitis and airsacculitis.
- **Clinical signs:**
  - Explosive spread of **respiratory signs** (tracheal rales, conjunctivitis, lacrimation and sneezing) in susceptible flock follows an incubation period of QB is 2-7 days.
  - **Neurologic disorders** may also be seen but are less consistent signs.
  - More **severe in young quail** (less 4 weeks of age). Infections are **milder or subclinical in birds over 8 weeks of age.**
  - Morbidity and mortality from 10 to 100% in young birds and the course of the disease in affected flocks varies from 1 to 3 weeks.

Inclusion body hepatitis (IBH)

- It is an adenovirus infection of young chickens characterized by sudden onset of mortality, short course, anemia and hepatitis with intranuclear inclusions.
- **Cause:**
  - Many virus serotypes of adenovirus group I (FAdV-1) are incriminated.
  - At least 19 serotypes had been reported.
  - The virus inclusions can be eosinophilic, large, round, or irregularly shaped with a clear pale halo.
- **Susceptibility:**
  - IBH mainly affect meat-type chickens aged 3-7 weeks.
  - Outbreaks of IBH have been reported in chickens less than 3 weeks and as old as 20 weeks. Certain chicken breeder flocks are more susceptible.
  - Cases of IBH and pancreatitis were reported in pigeons
  - This virus induce sever signs, severe growth retardation, lesions and immunosuppression in presence of IBDV or CIAV.
  - IBH was isolated from chicken, turkey geese, ducks and pigeons.

Diagnosis

- Confirmation of severe catarrhal tracheitis and bronchitis on histopathologic examination and demonstration of **intranuclear inclusion bodies**
- **Isolation and identification** of the causative adenovirus confirms the diagnosis of QB.
  - Isolation is accomplished by inoculation of **SPF-ECE via allantoic or yolk sac**.
  - QB virus induces **dwarfing, curling, thickening of the amnion, mottling (necrotic foci) of the liver and accumulation of urates in the mesonephros** within 2-4 days.
  - **Microscopically**, affected embryos reveal **hepatitis with intranuclear inclusion bodies**.
  - **Experimental subcutaneous inoculation of hamsters** leads to various kinds of neoplasms including fibrosarcomas, hepatomas, or hepatic carcinomas.
- **Serologic tests** are of limited value unless flock sampling is done on both an **acute and convalescent basis** to demonstrate definitive seroconversion. **AGPT and VN and HI (rat erythrocytes**) for FAdV-1 are applicable tests, HI

Lesions

- Skin of affected bird is pale, ectric and contains hemorrhages particularly over legs and breast.
- Hemorrhages are often present in skeletal muscles and under serous membranes.
- Liver usually show hepatitis, swollen, pale and friable with petecial or ecchymotic hemorrhages. Inclusion bodies are seen in hepatocytes
- Atrophy of spleen, thymus and bursa.
- Bone marrow is pale. Blood is thin and watery.

Signs

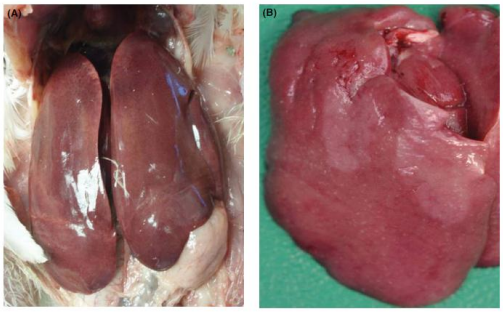
- Meat-type chickens aged 3-7 weeks are mostly affected
- Birds show sudden onset of mortality peaking after 3-4 days and may be stopped on day 5 or continued for 2-3 weeks.
- Morbidity is usually low; sick birds show ruffled feathers and die within 2 days or recover.
- Mortality ranged from 10% to 30%.

Hydropericardium Syndrome

Hydropericardium Syndrome was recognized in broiler characterized by high mortality and very low morbidity.

- **Cause:**
  - Adenoviruses FAdV-4 is considered to be the cause of this condition. There may be variation in virulence between strains.

- **Susceptibility:**
  - The affection occurred in broiler, breeding and laying chicken flocks.
  - Some FAdV-4 isolates can reproduce the condition by themselves, and other strains appear to require the assistance of an immunosuppressive agent such as CIAV.
  - The disease has also been seen in pigeons.



Lesions

- Accumulation of clear straw-colored fluid in the pericardial sac, pulmonary edema, swollen and discolored liver, and enlarged kidneys with distended tubules showing degenerative changes.
- Multiple areas of focal necrosis exist with mononuclear infiltration in the heart and liver. Basophilic inclusions are present in the hepatocytes.

Transmission & Signs

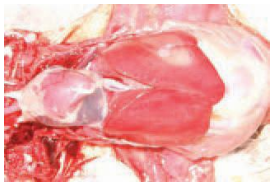
- The agent spreads well laterally among birds, and personnel appear to be important vectors.

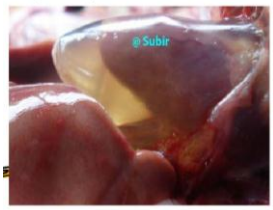
- **Signs:**
  - No typical signs could be observed.
  - It causes between 20 and 80% mortality, with very low morbidity. Typically, mortality starts at 3 weeks, peaks for 4-8 days and then declines.
  - Infection of layer birds results in a 10% drop in egg production.

Hemorrhagic Enteritis (HE)

t is an acute viral disease of turkeys 4 weeks of age and older characterized by rapid progression of depression, bloody droppings, and death. Clinical disease usually persists in affected flocks for 7-10 days. Due to the immunosuppressive nature of HE, secondary bacterial infections may extend the course of illness and mortality for an additional 2-3 weeks.

- **Cause:**
  - HE virus, MSD virus, and AAS virus are serologically related.
  - HEV, MSDV, and AASV have been classified according to source (turkeys, pheasants, or chickens), and referred to a virulent or avirulent based on the degree of pathology.
  - Serial passage of HEV and MSDV in turkey lymphoblastoid B-cell line derived from a Marek's induced tumor is considered standard system viral isolation as well as HE and MSD vaccine production.
  - The immunosuppression appears to occur with virulent as well as avirulent strains and the degree of immunosuppression seems to coincide with level of virulence.
  - Therefore, although virulent strains may certainly be considered pathogenic, avirulent strains should not be considered completely apathogenic.





Cont.

- Clinical outbreaks of HE occur in turkeys 6-11 weeks of age.
- Generally, poults younger than 3- 4 weeks of age are considered refractory:
  - maternal antibody
  - The need for some sort of target cell maturation.
- HE virus can be transmitted orally by feces contaminated litter.
- HEV is transmitted mechanically from infected to susceptible flocks via movement of infectious fecal or litter material.

Epidemiology

- Hemorrhagic enteritis has been a serious problem wherever turkeys are raised.
- Serologic surveillance show that HEV is widespread among adult turkeys.
- Turkeys, pheasants, and chickens are the only known natural hosts for HEV and related viruses.
- Host genetics appear to influence the severity of clinical disease and lesion formation in both turkeys and pheasants.

cont

- Spleen of infected birds are characteristically enlarged, friable, and marbled or mottled in appearance
- In dead poults tend to be smaller presumably due to blood loss and subsequent splenic contraction.
- Lungs may be congested, but other organs are generally pale.
- Enlarged livers and petechial hemorrhages in various tissues (inconsistent to be of diagnostic value).
- HEV intranuclear inclusions in liver, bone marrow, peripheral blood leukocytes, lung, pancreas, brain, and renal tubular epithelium.

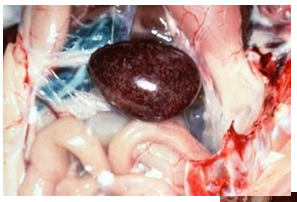
Lesions

- Dead poults routinely appear pale due to blood loss but are often in good flesh and have feed in their crops.
- The small intestine is commonly distended, grossly discolored, and filled with bloody contents.
- The intestinal mucosa is congested and in some individuals covered with a yellow, fibrinonecrotic membrane.
- Lesions are usually more pronounced in the proximal small intestine (duodenal loop) but often extend distally in severe cases.

Marble Spleen Disease

It is a condition affecting confinement-reared pheasants 3-8 months of age. Evidence of similar infections in other gallinaceous fowl exists. The clinical disease, is predominantly respiratory in nature with death occurring due to lung edema, congestion, and subsequent asphyxia

- **Epizootiology**
  - The causative virus is serologically indistinguishable from that of HE virus.
  - MSDV has been documented in confinement pheasant.
  - Marble spleen disease in pheasants occurs naturally in birds 3-8 months of age. It has also been reproduced experimentally in mature adult pheasants.
  - Some evidence suggests that pheasants are refractory to infection up to 4 weeks of age, either as a result of undetectable, low maternal antibody levels or a developmental lack of target cells.

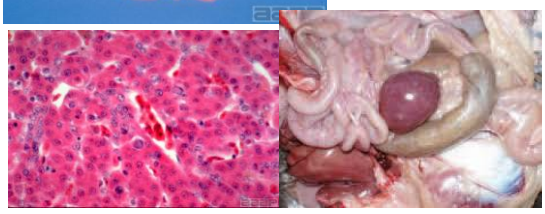


Signs

- Death of pheasants infected with MSDV is considered to be peracute or acute due to respiratory compromise.
- Signs, if present, consist of depression, weakness, and progressive dyspnea.
- Occasionally, a premortem nasal discharge has been noted.
- Mortality rates in pheasants naturally infected with MSDV have been reported to be 5-20% over a period of 10 days to several weeks.

Cont.

- **Transmission:**
  - THE virus can be transmitted orally by feces contaminated litter. HEV is transmitted mechanically from infected to susceptible flocks via movement of infectious fecal or litter material.



Lesions

- Pheasants infected with MSDV show enlarged, mottled (marbled) spleens and edematous, congested lungs.
- The virus produces intranuclear inclusions in liver, lung, kidney, bursa, and bone marrow no inclusions are seen in the gastrointestinal tract.

Signs

- Death of chickens infected with AASV is considered to be peracute or acute due to respiratory compromise.
- Signs, if present, consist of depression, weakness, and progressive dyspnea.
- Occasionally, a premortem nasal discharge has been noted In mature chickens with AAS, 8.9% mortality has been reported.

Adenovirus Associated Splenomegaly (AAS)

It has been described in broiler breeder chickens characterized by splenomegaly, pulmonary edema, and congestion.

- **Epizootiology**
  - Similarly, a high incidence of antibody in mature chickens suggests that many flocks are infected with AASV
  - In chickens, infection with AASV has been observed in broiler breeders 20-45 weeks of age.
- **Transmission:**
  - THE virus can be transmitted orally by feces contaminated litter.

Diagnosis

- Isolation and Identification of causative Virus from intestinal contents or splenic tissue.
- Positive identification of HEV, MSD, and AASV is commonly done by the use of AGPT
- Detection of viral DNA in fresh or frozen tissues by standard and nested PCR assays.
- The virus antibodies can be detected in plasma or serum of recovered birds by AGP while, ELISA for HEV is commercially available.

Lesions

- In broiler breeder chickens infected with AASV, Spleens of infected birds are characteristically enlarged, friable, and marbled or mottled in appearance and congested lungs.
- AASV produce typical adenoviral intranuclear inclusions in liver, lung, kidney, bursa, and bone marrow no inclusions are seen in the gastrointestinal tract.

Cont.

- **Types of Vaccine.**
  - Avirulent isolates of HEV and MSDV have been successfully used as live, water-administered vaccines.
  - Two forms of vaccine are in use.
    - One is a crude homogenate prepared from spleens of 4-6-week-old turkeys inoculated with the HEV avirulent I or HEV avirulent II.
    - The other is produced in vitro using MDTC-RP19 cells in suspension culture.
  - Both vaccines appear to produce adequate seroconversion and protection, and both are used

Prevention

- Prevention and control of HE, MSD, and AAS begin with good biosecurity
- **Vaccination:**
  - Three attenuated vaccine strains are recognized.
    - HEV avirulent I, a naturally attenuated strain of pheasant origin, propagated in turkeys, used to immunize turkeys;
    - HEV avirulent II, a naturally attenuated strain of turkey origin, propagated in turkeys, used to immunize pheasants
    - HEV CC HE, an attenuated strain, of pheasant origin, propagated in cell culture, used to immunize turkeys.

Egg Drop Syndrome (EDS)

The disease is characterized by transient respiratory signs and drop in egg production with changes in color, thin-shelled or shell-less eggs by healthy birds and a failure to achieve production targets. Vertically infected flock show these signs at 50% or peak egg production.

Importance:

Losses due to drop in egg production and increased costs of vaccination and preventive methods.

Treatment

- At the first sign of an outbreak, HE can be treated by subcutaneous or intramuscular injection of 0.5-1.0 mL of convalescent antiserum obtained from healthy flocks at slaughter.
- Treatment has not been described for MSD of pheasants or AAS of chickens, but it is presumed that a similar approach may be effective.
- Due to the immunosuppressive nature of these viruses, treatment for secondary bacterial infections, primarily colibacillosis, must be considered.

Epidemiology

- EDS virus has been isolated from chickens.
- The natural hosts for EDS virus are ducks and geese.
- Naturally outbreaks affect broiler breeders and heavy breeds producing brown eggs are more severely affected than white-egg producers.
- Chickens of all ages are susceptible to EDS virus infection.
- The disease at around peak egg production may be due to reactivation of latent virus.
- In many cases, chicks infected in ovo did not excrete virus or develop HI antibody until the flock had achieved greater than 50% egg production
- Quail is susceptible to infection and to develop classic signs of EDS.
- Chickens produced from EDS virus-infected eggs may be latently infected and fail to develop antibody;
- The virus will become reactivated and will be excreted at around the time of peak egg production, and EDS antibody will develop, which will prevent or reduce further excretion.
- Lateral spread is poor.

Etiology

- EDS virus is the sole member of the subgroup Atadenovirus, unrelated to the other subgroups and only one serotype is recognized as duck adenovirus type 1 (DAdV-1), variations have been demonstrated in its isolates.
- EDS virus agglutinate erythrocytes of chickens, ducks, turkeys, geese, pigeons, and peacocks **but doesn't** agglutinate rat, rabbit, and horse, sheep, cattle, goat, or pig erythrocytes.
- EDS virus replicates in the nucleus of infected cells where intranuclear inclusions were observed.
- EDS isolates can be divided into three genotypes.
  - EDS group included isolates from European chickens,
  - EDS group included viruses isolated from ducks in the UK.
  - EDS group has one virus isolated from chickens in Australia.
- EDS virus replicated to high titers in duck kidney, duck embryo liver, and duck embryo fibroblast cell cultures.
- The virus grew to high titers in goose cell cultures and allantoic sac of embryonated duck or goose eggs.

Signs

- The first sign is the loss of color in pigmented eggs, followed by production of thin-shelled, soft-shelled, or shell-less eggs.
- Thin-shelled eggs are often rough, with a sandpaper-like texture or had a granular roughening of the shell at one end of the egg.
- There is no effect on fertility or hatchability.
- Fall in egg production up to 40% is very rapid and extend to 4-10 weeks.
- In vertical infection, drop in Egg production usually occurr when production is between 50% and peak level due to reactivation of latent virus.
- Affected birds remain healthy. Although, inappetence and dullness have been described in some affected flocks. Transient diarrhea is probably due to the exudates from the oviduct.
- The virus has been isolated from healthy domestic ducks and from diseased ducks with a fall in egg production with rough, thin shells and severe diarrhea.

Transmission

- It is possible to divide EDS outbreaks into three types:
  - Classic form: vertical spread of virus via embryonated egg is the main method.
  - Endemic form: Infection results from spread of excreted virus of classic form leads to contamination of litter, egg trays and trucks. Needles or blades used for vaccination or bleeding of viremic birds can transmit infection.
  - Drinking water form: Spread of virus by droppings of water fowls to hens through contaminated drinking water.

Lesions

- Inactive ovaries and atrophied oviducts.
- Uterine edema and presence of exudates in the pouch shell gland.
- Flaccid ova, and eggs in various stages of formation in the abdominal cavity could be observed.
- Mild splenomegaly
- Intranuclear inclusion bodies can be seen from 7 days PI to the third day of abnormal egg production in epithelial cells of the infundibulum, tubular shell gland, pouch shell gland, isthmus, and in nasal mucosa and spleen infected chickens.

Prevention

- Replacement birds should be derived from uninfected flocks.
- Drinking water must be away from ducks and geese.
- **Vaccination:**
  - An oil-adjuvant inactivated vaccine is widely used and gives good protection against clinical EDS.
  - The birds are vaccinated between 14 and 16 weeks of age.
  - If uninfected birds are vaccinated, EDS HI titers of 8-9 $\log_2$ can be expected. If the flock has been exposed previously to EDS virus, HI titers of 12-14 $\log_2$ may be found.
  - Vaccinal immunity lasts at least 1 year.
  - Vaccinated birds are protected against disease and do not appear to excrete EDS virus.
- When vertical or lateral transmission of EDS virus is a possibility, flocks in danger can be protected by vaccination in the growing period.

Diagnosis

- EDS should be suspected when there is a falls in egg production of healthy birds and eggshell changes.
- Virus isolation from the pouch shell gland and abnormal eggs.
- HI, ELISA, SN, DID, and IFA tests are of similar sensitivity for virus identification while HI is the test of choice for serological diagnosis.
- The EDS virus agglutinates erythrocytes from chickens, geese, turkeys, and ducks.
- A suitable HI test uses 4 HA units of antigen, an initial 1:4 serum dilution, and 0.8% chicken erythrocytes.
- **Differential Diagnosis:**
  - EDS must be differentiated from infectious causes as ND, CELO, SHS and non infectious causes.