



Prevention and Control of Newcastle Disease

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Abstract – Newcastle disease (ND) is very important disease of poultry birds. The ND virus has capability to infect wide range of poultry birds including domestic, commercial layer, broiler and breeder flocks, and is responsible for high morbidity and mortality. The ND is prevalent in domestic (rural) and commercial flocks, and is responsible for heavy economic losses in developing countries like Pakistan. Many factors include, lack of proper vaccination, adaptation of quarantine measures, poor bio-security practices etc. are responsible for outbreaks of ND. The ND virus infects respiratory, digestive and nervous system and in severe cases may cause high economic losses. Wide ranges of clinical signs are observed in affected birds and disease can be diagnosed based on clinical signs and laboratory isolation of virus. The disease can be prevented through vaccination and adaptation of strict bio-security and quarantine control measures. During the outbreak of disease proper disposal of dead birds and zoning of the area can help to control the disease in surrounding flocks.

Keywords – Newcastle Disease, Prevalence, Clinical Signs And Symptoms, Prevention, Control.

I. INTRODUCTION

Pakistan is an agricultural country and poultry production has become an important sub-sector of agriculture (Mushtaq, 1994). Broiler and layer flocks are important source of meat and eggs, respectively. Poultry meat is one of the cheaper sources of animal protein. Every family in rural and every 5th family in urban areas is associated with poultry production activities in one way or the other (Sadiq, 2004). The annual growth rate of poultry in Pakistan is 7-8 % as poultry meat contributes 26.8 percent of total meat production in the country (GOP, 2012).

Poultry production is continuously increasing in Pakistan. Infectious diseases are one of the factors responsible for decreased production of poultry products. Poultry flocks are encountered with Newcastle disease, Infectious Bronchitis, Infectious Bursal disease (Gumboro), Egg drop syndrome, hydro-pericardium syndrome and avian influenza which are responsible for high economic losses (Qureshi *et al.*, 1981; Siddique *et al.*, 1986; Numan *et al.*, 2005; Siddique *et al.*, 2012; Cheema *et al.*, 2011).

ND is one of the major important viral diseases of poultry birds which have caused huge economic losses to farmers in recent past. ND is transmissible and notifiable disease that has the potential of very rapid and wide spread, and has socio-economic consequences in international trade of animals and animal products. Incidences of ND and other OIE listed diseases like Avian Influenza (AI) were reported in Pakistan (Mustafa and Ali, 2005; Cheema *et al.*, 2011) which had badly affected the economy and trade of poultry products.

ND is caused by a single stranded, non segmented, negative sense RNA virus, also known as Avian paramyxovirus 1 (APMV-1). ND is the contagious disease of domestic, commercial, wild, pet and water living birds. The ND affected birds exhibit the symptoms of irregularities of respiratory, nervous and digestive system. Mortality due to ND is based on strain of ND virus. Severity of ND is also based on age, immune status and the ability of bird to accept the disease (Okwor *et al.*, 2007). Among avian species the poultry flocks are commonly affected with this disease. Chicken is most susceptible while ducks and geese are least susceptible to ND. ND is regarded as one of the major poultry diseases of poultry (Vyslouzil and Dhonal, 1988; Javed *et al.*, 1994; Khan *et al.* 2000).

A. Transmission of ND virus

The ND virus can be transmitted directly from diseased to healthy birds through oral and respiratory route. The infected birds shed ND virus in high quantities in their fecal droppings, nasal discharge, lacrimal discharge and exhaled air and can infect healthy birds (Nawanta *et al.*, 2008). The utensils, feeders, water drinkers, contaminated feed, feed bags, contaminated water, vaccinating and debeaking crews, human movements, eggs crates, cages, visitors, owners etc. can also transmit the virus from one place to another. Migratory birds and water fowl can also transmit ND. Transmission of ND is through horizontal means only. The newly hatched chicks in hatcheries may become infected with contaminated shells, trays, chick boxes, etc. Due to aerosol mode of spread of disease the ND virus may affect all the poultry birds within the confined areas.

B. Prevalence of ND in poultry birds

Poultry is encountered with both infectious and non-infectious diseases (Qureshi *et al.*, 1981). Among infectious diseases ND is prevalent in rural and commercial poultry flocks. Mustafa and Ali (2005) recorded 24.66% and 15.66 % prevalence of ND in Fayoumi and Desi birds, respectively, in district Sheikhpura (Pakistan). Chukwudi *et al.* (2012) found prevalence of 3.2% of ND virus in non-vaccinated apparently healthy commercial chickens.

C. Signs and symptoms of ND

Neurotropic velogenic ND virus (NVNDV) affects the nervous system and causes paralysis of legs and wings, the neck twists to one side the birds may depict the picture of star gazing like torticollis, birds move in a circle and exhibit opisthotonic posture. Viserotropic velogenic ND virus (VVNDV) affects the digestive tract of birds, results in decrease feed and water intake, and copious greenish white diarrhea. Pneumotropic velogenic ND virus (PVNDV) causes respiratory signs in chicks which result in difficult breathing (Kommers *et al.*, 2002; Oladele *et al.*, 2005).

The attack of ND spreads rapidly. The incubation period of ND virus ranges from 2 to 15 days. Cough, flu sneezing, tracheal rales, fever, uneasiness, depression, watery discharge from nose, decreased feed intake, decreased water intake, diarrhea, conjunctivitis, ruffled feathers, torticollis, blindness was observed in birds (Brown *et al.*, 1999; Kommers *et al.*, 2002; Pansota *et al.*, 2013). Diarrhea, nervous signs, shivering and paralysis of legs and wings has been observed in pigeons (Shaheen *et al.*, 2005). The clinical signs and symptoms of ND also include depression, weakness, loss of appetite, dehydration, inability to stand, cyanosis of comb and wattle, greenish watery diarrhea, nasal and eye discharges, decreased egg production, loss of weight followed by death (Pazhanivel *et al.*, 2002; Pansota *et al.*, 2013). There are many factors which effect severity of clinical signs of ND in birds mainly; age, route of infection, immune status and concomitant environmental stress. Young birds have more severe and acute disease in comparison to older birds (Allan *et al.*, 1978; Alexander, 2003). The intravenous inoculation / infection elicits neurologic signs and aerosolization of high viral doses impact the upper respiratory infection (Alexander, 1995).

There is also species variation regarding expression of clinical signs in birds. The clinical signs in chickens are recognizable at second day of the onset of the disease (Brown *et al.*, 1999; Kommers *et al.*, 2002; Kommers *et al.*, 2003; Wakamatsu *et al.*, 2006; Susta *et al.*, 2011), birds become off feed and dull on third day (Oladele *et al.*, 2005), and chicks become severely depressed and inactive with hard ruffled feathers on fourth day, prostrated position and open mouth breathing starts on fifth day of ND infection (Kommers *et al.*, 2002), nervous signs i.e. blindness and torticollis and incoordination on seventh day of ND virus infection (Alexander, 1997; Brown *et al.*, 1999; Kommers *et al.*, 2002; Sa'idu *et al.*, 2006; Oladele *et al.*, 2008b; Pansota *et al.*, 2013). In one study birds became anorexic, suffered from greenish diarrhea, dyspnoea, and exhibited respiratory signs, with nasal

discharge and difficult breathing along with torticollis and in-coordination on fourth day of NDV infection (Shahzad *et al.*, 2011). The pigeons develop ND after fifth day of infection and became dull, anorexic and have droopy and paralyzed wings (Oladele *et al.*, 2008). Loss of appetite, greenish diarrhea, swelling of head, respiratory distress, sneezing and coughing was observed in turkeys (Abdul Aziz and Arp, 1983; Adair *et al.*, 1989) and guinea fowls (Haruna *et al.*, 1993; Mohammad *et al.*, 1996), quails (Oladele *et al.*, 2008a). The redness of eyes, and swelling around neck and ear was also seen in infected birds. In case of acute outbreak of ND there may be sudden death of birds in the flock in a period of overnight incubation with virulent strain of ND virus. Sometimes only death is the symptomatic feature of ND in poultry flocks. Rise in temperature, dullness, thirst, anorexia, staggering gait, shaking of head and paralysis of legs and wings in last stages is also observed (Abbas *et al.*, 1992). Birds also become lame, have drooping wings, unable to fly, walk in circles and older birds may also moult.

D. Gross lesions

In dead birds many gross lesions are observed. In trachea mucous in excess amount and pin point hemorrhages in the proventriculus is observed. The intestinal serosa becomes reddened and the blood may get accumulated in the liver, lungs and heart, and dehydration of muscles. Lesions also include hemorrhagic larynx, hemorrhagic trachea, congested lungs and cloudy air sacs containing exudates (Crespo *et al.*, 1999; Kommers *et al.*, 2002; Oladele *et al.*, 2005; Piacenti *et al.*, 2006), multi focal hemorrhages in the mucosa of proventriculus, caeca and small intestine of infected birds (Kommers *et al.*, 2002). The gross lesions of ND were not observed in birds up to fifth day of onset of disease (Brown *et al.*, 1999; Kommers *et al.*, 2002; Oladele *et al.*, 2005). The multi focal linear hemorrhages and ulcers have been observed in digestive tract including oral cavity, esophagus, proventriculus and intestine in chicken (Abbas *et al.*, 1992; Alexander *et al.*, 1997; Kommers *et al.*, 2002; Piacenti *et al.*, 2006; Sa'idu *et al.*, 2006; Oladele *et al.*, 2008b; Pansota *et al.*, 2013) and necrotic spots on kidneys, pin point hemorrhages on heart and proventriculus in pigeons (Shaheen *et al.*, 2005), and multi focal linear hemorrhages in the larynx and trachea of game birds (Crespo *et al.*, 1999). Barton *et al.* (1992) observed mild air sacculitis and focal pulmonary consolidation and caseous plaques in trachea in pigeons. Central nervous lesions are seen in the cerebellum, brain stem, mid brain and spinal cord, and consist of neuronal degeneration, gliosis, endothelial cell hypertrophy and perivascular lymphocytic accumulation, congestion and oedema in brain and torticollis are observed in pigeon (Shaheen *et al.*, 2005) with no gross change in brain in game chicken (Crespo *et al.*, 1999). Tracheal hemorrhages, splenomegaly, alveoli filled with edematous fluid and infiltrated with mononuclear cells on fourth day of infection and lymphocyte degeneration in bursa and lymphoid hyperplasia in spleen on eighth and tenth day are also observed (Shahzad *et al.*, 2011). The muscles of breast, thighs becomes congested, carcasses becomes

emaciated, dehydrated and has lesions of ND in digestive and respiratory organs in pigeons that died due to ND (Oladele *et al.*, 2008). The gross lesions also include ulcers with raised borders on the mucosa of proventriculus, pneumonic lungs, and hemorrhages in trachea air sacs, brain and spleen (Abbas *et al.*, 1992; Pazhanivel *et al.*, 2002). The hemorrhages in intestine and proventriculus, tracheitis, air sacculitis, congestion and oedema in the brain and conjunctivitis is observed in turkeys (Abdul Aziz and Arp, 1983; Adair *et al.*, 1989), guinea fowls (Haruna *et al.*, 1993; Mohammad *et al.*, 1996) and quails (Oladele *et al.*, 2008a). The ovary becomes flaccid and contains congested, discoloured, degenerating follicles. Subcutaneous oedema occurs over the head, eyelids, comb, wattles and neck.

E. Histopathology of affected organs

The histo-pathology of internal organs of ND affected bird had depicted pathological changes. The epithelial sloughing, congestion of blood vessels of mucosa and infiltration of inflammatory cells in lamina propria of intestine, catarrhal tracheitis, congestion and necrosis in mucosa of trachea and alveoli of lungs filled with exudate along with infiltration of lymphocytes, emphysema and necrosis was observed in birds infected with ND virus (Pansota *et al.*, 2013), along with micro-hemorrhages and sloughed epithelium in lamina propria of trachea, congestion and hemorrhages in para-bronchial region and inflammatory exudation in alveoli (Shahzad *et al.*, 2011). Other findings indicated epithelial hyperplasia of trachea, congestion of lungs, alveoli filled with edematous fluid and infiltration of mononuclear cells along with severe pulmonary congestion (Kommers *et al.*, 2002) and lymphoid hyperplasia in lungs (Brown *et al.*, 1999) in ND infected birds.

F. Diagnosis of ND

Although ND can be diagnosed based on signs, symptoms and postmortem findings. But the clinical signs and gross lesions cannot accurately distinguish between ND and Avian Influenza. As a result the tentative diagnosis of ND requires laboratory tests for confirmation of ND. The nasal discharge, fecal droppings, blood or internal organs (liver, kidneys, spleen, trachea, lungs, heart and intestinal contents) of morbid or dead birds can be collected and processed for isolation of ND virus in the laboratory. Virus isolation and identification is regarded as the confirmatory test for ND (Cattoli *et al.*, 2011; Alexander, 2003; Alexander and Senne, 2008; Alexander *et al.*, 1984). The confirmation of ND virus can be done through PCR, ELISA, etc. The pathogenicity of ND virus can be checked through intra-cerebral pathogenicity index (ICPI), intra-vertebral pathogenicity index (IVPI) or mean death time (MDT). Based on virulence the ND virus can be classified as velogenic (highly virulent), mesogenic (moderate virulent) or lentogenic (non-virulent) strain of NDV (Alexander, 2003; Alexander, 1998; Huang *et al.*, 2004; Orsi *et al.*, 2009). Velogenic viruses are further subdivided according to predominant clinical sign and symptoms produced in infected birds, into viscerotropic velogenic (VVND), neurotropic velogenic (NVND) and pneumotropic velogenic (PVND) strains.

II. ECONOMIC LOSSES DUE TO ND

Diseases cause heavy economic losses to poultry farmers (Qureshi *et al.*, 1981; Siddique *et al.*, 1986; Numan *et al.*, 2005; Cheema *et al.*, 2011; Siddique *et al.*, 2012). The economic losses due to ND are due to high mortality and morbidity and decreased production of eggs from layer and production of eggs of low quality from breeder flocks. The treatment cost along with extra management of poultry flocks during course of the disease also enhances the economic losses due to ND.

A. Morbidity and mortality in birds

ND is responsible for high morbidity and mortality in birds of all age groups (Calnek, 1991). Virulent strain of ND virus may cause high mortality (Alexander, 1997). ND virus differs in virulence and has been grouped into 5 patho-types: viscerotropic velogenic, neurotropic velogenic, mesogenic, lentogenic and asymptomatic enteric (Beard and Hanson, 1984). VVND and NVND viruses may cause 100% mortality while mesogenic strain causes moderate disease and mild reduction in egg production (Alexander, 1997). ND is mostly caused by velogenic strains than mesogenic or lentogenic strains. The disease caused by velogenic strain may cause 80-90% mortality in adult birds (Eisa and Omer, 1984; Claudia *et al.*, 1996; Pansota *et al.*, 2013). The severity of disease varies greatly, spanning from per-acute disease with almost 100% mortality to subclinical disease with no lesions (Alexander, 1998; Orsi *et al.*, 2009; Yan *et al.* 2011). Velogenic NDV can cause the very high mortality with in 2-4 days (Brown *et al.*, 1999; Kommers *et al.*, 2002; Kommers *et al.*, 2003; Wakamatsu *et al.*, 2006; Susta *et al.*, 2011; Pansota *et al.*, 2013).

B. Production losses due to ND

ND is responsible for increased production losses in layer and breeder flocks, resulting in devastating effect on poultry production (Alexander, 1980). Velogenic strains of ND cause marked reduction in egg production, while mesogenic strains of NDV cause moderate disease and reduction in egg production (Alexander, 1997). The commercial poultry farming encountered problems with ND and caused high mortality and morbidity in layer flocks, as a result the hen house and hen day production is markedly reduced in affected flocks. The affected layer flocks lay less number of eggs, or produce soft shell or shell less eggs. In layer poultry flocks there may be 90% drop in egg production. As the ND can affect the poultry birds of any age, the outbreaks of disease during start of egg production and peak production season result in low income. Production of poultry meat from broiler flocks is also affected due to ND. The broiler birds become weak, resulting in decreased weight gain and decreased Feed conversion ratio (FCR). The high mortality in broiler flock can result in decreased production of white meat.

C. Treatment cost and meat and egg quality

The treatment cost on the ND affected flocks increases economic losses. The eggs obtained from affected flock become light in colour, egg shells become thin and become rough along with decreased quality of egg, albumin may be watery, thickness of egg white is

decreased and there is decreased fertility of breeder eggs resulting decreased hatchability. The reproductive system may be permanently impaired, and egg production performance does not resume to peak production. The egg quality of ND affected flocks is also decreased due to the use of antibiotics for the prevention of secondary infections during the course of disease result in antibiotic residues in meat and eggs. Thus meat and eggs become unfit for human consumption due to high levels of drug residues.

III. PREVENTION AND CONTROL

The following measures can be adopted for prevention and control of ND in poultry flocks.

A. Vaccination

Vaccination is the most successful tool for prevention of ND. Non usage of ND vaccine in rural areas is one of the factors for outbreak of ND. For the prevention of ND in chicks, the birds should be vaccinated against ND. The vaccine against the local strain of ND virus prevalent in the respective areas may be used for vaccination against ND. The improper vaccination may result in the outbreak of ND (Khan *et al.*, 2000; Vyslouzil and Dohnal, 1988; Mustafa and Ali, 2005). The ND is the major issue of rural (domestic) poultry of Pakistan especially Aseel (Desi) birds are prone to ND. Introduction of new ND virus strains against which local birds have no or very low immunity may lead to vaccine failure (Numan *et al.*, 2005) in rural poultry birds. Routine vaccination of rural poultry flocks against ND can help preventing ND. The local ND vaccine commonly available in the market helps protect the chicks against local strains. Based on the age of birds and manufacturers recommendations and guidelines should be followed for vaccination. Different routes of vaccination are; eye drop (intra-ocular), intra-nasal (spray), sub-cutaneous and drinking water. In case of use of ND vaccine in drinking water, use of medications and sanitizing agents in drinking water must be discontinued 24 hours before drinking, and must be resumed after 24 hours following vaccination. Non-chlorinated water should be used for vaccination.

B. Preventing vaccine failure

Vaccine failure results in the outbreak of ND (Khan *et al.*, 2000; Vyslouzil and Dohnal, 1988; Mustafa and Ali, 2005). In spite of vigorous and regular vaccination, ND is still a havoc to the poultry flocks and outbreaks have occurred even in vaccinated flocks (Siddique *et al.*, 1986). Vaccine failure results from, inadequate method of vaccination, vaccination during concurrent incubation period of ND, stress of extreme weather conditions (winter or summer), transportation of birds after vaccination, etc. Poor quality of vaccine is also one of the factors that can cause vaccine failure (Chaudhry and Chaudhry, 1996; Numan *et al.*, 2005). Poor vaccine quality is due to poor manufacturing standards, low quantity of antigen (immunogen), use of expired vaccines, faulty application in birds, lack of proper storage, exposure to direct sunlight, poor vaccine handling during transportation, non-maintenance of supply cold chain, (Vui *et al.*, 2002). The vaccine failure may also result due to mycotoxins and or

drug induced modulation, stress to birds, concurrent infectious agents, malfunctioning of host defense mechanisms or presence of high titers of maternal antibodies titer (Chaudhry and Chaudhry, 1996; Muhammadamin and Qubih, 2010; Li *et al.*, 1999). Preventing vaccine failure through monitoring quality of vaccine and host immune system can prevent ND in poultry flocks.

C. Boosting immune system of birds

Immunity level (antibodies titer) of breeder flocks against ND virus must be checked and maintained at regular intervals through vaccinations. Low serum antibody titers against ND are often found in even in vaccinated flocks. Any type of stress in birds can break the immunity level of bird and serum antibody titer level may decrease. The low serum antibodies titers cannot protect birds from ND. Unsuitable vaccination schedule, improper vaccination techniques, impaired immune competence due to immunosuppressive substances in feed or immunosuppressive diseases like Infectious Bursal Disease (IBD) are the possible factors for low level of serum antibodies against ND (Numan *et al.*, 2005). The low level of antibodies against ND in non-vaccinated chicks of early ages is also due to low levels of maternally derived antibodies from parent flock transmitted through egg yolk and may not protect chicks from ND (Awan *et al.*, 1994; Numan *et al.*, 2005). Heat stress and water deprivation result in production of steroids and cause immunosuppression (Sil *et al.*, 2002). Impaired immune system of birds is also a risk factor for high incidence and prevalence of ND in chicks. Immunostimulation of a bird leads to increased antibody production, increased cellular immune responses and increased macrophage phagocytic ability which results in enhanced resistance to bacterial and viral infections (Muhammadamin and Qubih, 2010; Dugas *et al.*, 1999; Emad and Amjad, 2007; Numan *et al.*, 2005). Deficiency in essential nutrients in feed also poses risk of ND. High stocking densities, over-crowding and intensive poultry production result in break down of immunity and is also one of the factors for severe outbreaks of ND. Use of immune booster products enhance immune response against ND in immunosuppressed birds (Muhammadamin and Qubih, 2010). For boosting the immune response of birds the feed may be supplemented with vitamin E / Selenium and minerals.

D. Biosecurity

Inadequate biosecurity is conducive for spread of ND (Okwor and Eze, 2010). The ND can be prevented through strict bio-security and restricting movements of infected birds. Proper distance should be kept in between poultry farms during construction of new poultry farms. Broiler poultry farm should be constructed at a distance of 1km and breeder farm should be at a distance of 3km from nearby poultry farm. The strict biosecurity at poultry farm helps preventing the viral and bacterial diseases. In this regard movement of persons within and out of farm should be strictly monitored and common people should not be allowed to enter in the poultry farm. Moreover, the free movements of wild birds, pet birds, watch dogs and dairy animals within the farm area should be restricted. The

number of visitors to poultry house may also be reduced to minimum. Clean clothings should be given to visitors for purpose of visit of the poultry farm. The personnel of commercial poultry farm including poultry attendants, electricians, etc. should not rear backyard poultry at their living places, moreover live poultry birds markets should not be visited. The employees should wear dry and clean dresses during working in poultry house. The good sanitation and sewerage system must be maintained at the poultry farms so that the spread of disease could be prevented. The spread of ND in the surrounding areas should be checked and preventive measures should be adopted accordingly for the prevention of ND in poultry flocks.

E. Minimizing stress on birds

Stress to birds include production stress, concurrent disease, over stocking, heat stress, cold stress, deprivation of feed and water, transportation for long duration, wet litter, ammonia accumulation in shed in winter season, etc. Respiratory and digestive distress of poultry flocks due to *Mycoplasma gallisepticum* and salmonella infection cause stress to poultry and may enhances the spread of ND (Siddique *et al.*, 2012). Therefore mycoplasma free flocks must be maintained. During the period of maximum egg production the stress on bird is enhanced, at that time provision of balanced feed, drinking water of good quality and maintenance of optimum antibodies titer against ND can help to avoid outbreak of ND.

F. Quarantine measures

The interaction of healthy birds with non-vaccinated and migratory birds resulted in the outbreak of ND (Khan *et al.* 2000; Vyslouzil and Dohnal, 1988; Mustafa and Ali, 2005). The spread of ND in some areas is normally via newly introduced birds (Tu *et al.*, 1998). In case of mixing of new birds with old birds the new birds should be kept separate for a period of one week and new birds should be vaccinated during quarantine period before mixing with old birds.

G. Vectors Control

Farm utensils, wild animals, like rats, reptiles and rodents may act as physical vector and transporter of ND virus and cause the spread of disease. The utensils of flocks like feederers, egg crates, brooders affected with ND should not be used for feeding and watering of healthy flocks, and these should be properly washed with disinfectants before using for healthy flocks.

H. Proper management

The occurrence of ND could be due to poor preventive measures, unhygienic conditions, poor brooding arrangements, lack of proper interval (down time) between successive flocks and poor knowledge about rearing the rural poultry on scientific basis (Mustafa and Ali, 2005). Many factors including rearing of multi age poultry flocks effect on the spread of ND in birds (Abdul Aziz and Arp, 1983; Alexander, 1995; Alexander, 2003; Alexander and Senne, 2008; Kotani *et al.*, 1987; Cattoli *et al.*, 2011; Okwor *et al.*, 2007). Management practice of all in or all out rearing and breeding of chicks should be adopted. The farming of one age bird group at farms helps efficient management of chicks and helps complete disinfection of

farm during the interval between the housing of poultry groups. The trucks used for transportation of feed and feed bags should be properly fumigated, and tyres should be disinfected properly before entering the poultry house. The poultry shed should be properly fumigated with formalin and KMnO_4 solution before rearing new flocks in the sheds. The drinking of birds in pond, pool, etc may also be the source of infection in new birds. Poor ventilation and poor housing is responsible for spread of ND in poultry flocks (Khawaja *et al.*, 2005; Coutts, 1987).

I. Killing of ND virus

The ND virus, i.e. paramyxovirus, is resistant to a pH 2-12 and temperature upto 130°F (56°C) for 3 hours, and survive even at freezing for indefinite periods. ND virus can survive for several weeks in warm and humid environment, in manure, utensils and other materials of poultry house. Within feces and dust in a poultry house the ND virus can survive for long periods (up to 12 months). For complete killing of ND virus proper disinfection of farm with physical and chemical method may be used. Extended drying and ultraviolet light kill the virus. The spray of formaldehyde, etc can also be used to kill the virus. White wash of poultry house with lime water can also completely kill or minimize the load of virus in the shed. Fumigation and exposure to direct sunlight can kill the ND virus.

J. Rearing of disease free poultry flocks

The parent flocks infected with *Salmonella pullorum* and *Mycoplasma gallisepticum* results in infection of uterus and ovaries resultant in vertical transmission of diseases through eggs. Day old chicks should be bought from hatcheries where chicks are free from salmonella and mycoplasma in parent flocks. In order to raise healthy poultry flocks only disease free poultry flocks must be maintained (Siddique *et al.*, 2012).

K. Zoning of outbreak area

In case of outbreak of ND the zoning of the area should be done and movement of farm personnel, workers, laborers, etc. should be restricted and standard operating procedures / protocols (SOPs) determined as per prevalent conditions must be followed for collection of dead and diseased birds, etc. Outbreaks are eradicated with quarantines, movement control, depopulation of all infected and exposed birds, through cleaning and disinfection of premises.

L. Proper disposal of dead birds

As dead birds are source of spread of ND, a mortality pit may be constructed within the boundary wall of the farm area. All the dead birds should be buried in the pit for proper disposal and for preventing spread of ND.

M. Regular surveillance of carrier birds

Regular sero-surveillance is required to continuously monitor the spread of diseases (Cheema *et al.* 2011). ND recovered birds may carry and excrete NDV virus through fecal droppings and nasal discharge for months (Kaletea and Baldauf, 1988). The carrier birds should be screened and slaughtered. Vaccinated birds may show no clinical signs at all on challenge with virulent virus but will become infected and excrete the virulent virus for up to 2 weeks (Miller *et al.*, 2009).

N. Maintenance of farm record

All type of record of purchase and sale of poultry birds must be maintained. The record of visitors, poultry veterinarians, livestock assistants, along with date wise record of vaccination, medication, daily feed intake, vitamin supplementation, etc. must be maintained. The maintenance of record helps in investigation of cause of disease outbreak and helps in adopting proper and timely control measures during the course of outbreak of disease.

O. Passive immunization

The ND in breeder flocks can be controlled through passive immunization by use of hyperimmune serum (HIS). The use of HIS has protective effect in ND affected chicks. HIS has been successfully used to decrease the morbidity and mortality in affected birds. It is found that mortality and morbidity rate is low in chicks passively immunized with HIS while mortality is high in the chicks not passively immunized with HIS during ND virus infection (Pansota *et al.*, 2013). Immune protection / passive immunization results in diminishing of signs and symptoms and revival of health of ND affected birds in a short time (Umino *et al.*, 1990; Pansota *et al.*, 2013).

P. Prevention of secondary infections

During the course of the disease the birds become vulnerable to secondary bacterial infections. The use of supporting medicine during the course of disease may prevent secondary bacterial infection in birds. Secondary infections of respiratory system due to *Mycoplasma gallisepticum* infection in poultry may enhance the spread of ND (Siddique *et al.*, 2012). The antibiotic treatment may be given to prevent secondary bacterial infection in birds during the course of the disease.

Q. Good hygiene measures

Bad sanitation and poor hygiene of poultry house favour the out break of bacterial and viral diseases in poultry farm. Wet litter due to leakage of water supply or drinking utensils, excess humidity, fecal droppings on feeding trays, drinkers, inside egg laying nests and windows, accumulation of bad air in poultry house, broken eggs, etc. make the environment unhygienic. For preventing of ND litter should be completely dry and good hygienic measures should be adopted.

As Pakistan is developing country and ND is a major risk to poultry flocks causing huge economic losses. Presently there is already low production and high cost of animal protein available from form beef and mutton source. The cheap source of animal protein from poultry flocks is threatened due to outbreaks of ND. The ND has social, economical and trade impacts at regional, national and international level. The raising of poultry flocks on modern lines and preventing diseases in poultry flocks in particular ND can decrease economic losses to poultry industry. The poultry production is also a source of food security for developing countries like Pakistan. Controlling ND can be profitable for poultry farmers and the production of eggs and poultry meat could be enhanced in the country and shortage of animal protein can be reduced, and per capita availability of animal protein can be increased.

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