Avian Colibacillosis: A Review

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Abstract: Avian colibacillosis is considered to be the major bacterial diseases in the poultry industry world-wide. Colibacillosis is the most common avian diseases that are communicable to humans. Avian pathogenic Escherichia coli (APEC) strains cause severe respiratory and systemic diseases, threatening food security and avian welfare worldwide. A better understanding of the information addressed in this review article will assist the poultry researchers and the poultry industry in continuing to make progress in reducing and eliminating avian colibacillosis from the poultry flocks, thereby reducing potential hazards to the public health posed by these.
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Introduction

Escherichia coli (*E. coli*) is a normal inhabitant of birds' lower gastrointestinal tract. It is also commonly present in the pharynx and trachea. Most of *E. coli* strains are safe, although some strains are virulent and able to induce diseases in birds. Those ones were named APEC, for avian pathogenic *E. coli*, with the intestine constituting their reservoir (**Ewers *et al*., 2009**). Large numbers of *E. coli* are maintained in the poultry house environment through fecal contamination. In poultry, APEC strains cause a wide range of localized and systemic infections commonly called avian colibacillosis. Avian colibacillosisis a cause of mortality and morbidity associated with economic losses in the poultry industry throughout the world (**Zhuang *et al*., 2014**). Economic losses can be cause due to decrease hatching rates, decrease egg production, mortality, low production, carcass condemnation at slaughter and costs associated with treatment and prophylaxis. However, even if there is no doubt about economic impact of avian colibacillosis, it is hard to find data on the economic cost of this disease for the poultry industry (**Barnes, et al., 2008**). APEC could infect all types of birds at all ages in all types of poultry production, causing localized and systemic types of colibacillosis acting either as a primary or secondary agent (**Barnes, et al.,2008**). The most typical forms of localized infection due to APEC as a primary pathogen are infections of the reproductive tract, omphalitis and yolk sac infection. Infections of the reproductive tract includes salpingitis/peritonitis/salpingoperitonitis syndrome (SPS), which is very common in laying hens, and the *E.coli* peritonitis syndrome (EPS) which is more acute and septicaemic than SPS and affects laying hens from the start of egg production to peak production. The route of infection seems to be of respiratory and vaginal origin (**Landman, et al., 2013**). Omphalitis and yolk sac infection occurs by fecal contamination of eggs or in ovo during egg formation when laying hens suffered SPS. Furthermore, as a secondary opportunistic bacterium, *E.coli* can play a role in some bone and joint infections affecting poultry flocks. However, the most studied syndrome is the systemic form of colibacillosis from arespiratory origin that induces colisepticemia. Colisepticemia occurs in stressed and immunocompromised birds due to deteriorated environmental conditions of poultry houses such as high level of dust and ammonia, mycoplasmal infection, and infectious bronchitis virus (IBV) and Newcastle disease virus infections, including vaccine strains. These biotic and abiotic factors could lead to an impaired immune response and/or deciliation of tracheal epithelial cells (**Nagaraja *et al*., 1983; Kotani *et al*., 1987; Matthijs *et al*., 2009**). This defect in epithelial mechanical defenses favors colonization of the upper and lower respiratory tract by APEC strains that are present in the environment, which will finally lead to respiratory infection APEC is thus assumed to cross the respiratory epithelia and penetrate deeply into the mucosa and submucosa to reach blood stream causing septicemia. Birds surviving to septicemia develop subacutefibrinopurulentairsacculitis, pericarditis and perihepatitis. Although airsacculitis is observed, it is unclear whether it results from primary respiratory exposure or from extension of polyserositis. Furthermore, sequelae of colisepticemia could also lead to arthritis, osteomyelitis, peritonitis and salpingitis (**Barnes, et al., 2008; Dziva and Stevens 2008).**

Epidemiology of Avian Colibacillosis

APEC spread into various internal organs and cause colibacillosis characterized by systemic fatal disease (**La Ragione and Woodward 2002**). *E.coli* isolates pathogenic for poultry commonly belong to certain serogroups, particularly the serogroups O78, O1, and O2, and to some extent O15 and O55 (**Chart *et al*., 2002**). In domestic poultry, avian colibacillosis is frequently associated with *E.coli* strains of serotypes O78:K80, O1:K1 and O2:K1 (2- Filali E). The avian colibacillosis was found widely prevalent in all age group of chickens (9.52 to 36.73%) with specially high prevalence rate in adult layer birds (36.73%) (**Rahman *et al*., 2004**). The risk for colibacillosis increases with increasing infection pressure in the environment. A good housing hygiene and avoiding overcrowding are very important. Other principal risk factors are the duration of exposure, virulence of the strain, breed, and immune status of the bird (**McGruder and Moore 1998**). Every damage to the respiratory system favours infection with APEC. Several pathogens, like NDV, IBV and MG, both wild type and vaccine strains, may play a part in this process. An unfavourable housing climate, like an excess of ammonia or dust, renders the respiratory system more susceptible to APEC infections through deciliation of the upper respiratory tract (**Barnes and Gross 1997**) Pulsed field gel electrophoresis (PFGE) is considered to be the most reliable molecular finger-printing technique to differentiate organisms but restriction fragment length polymorphism (RFLP) is the one that is used most frequently. However, both techniques require large quantities of DNA, are time consuming, and require expensive equipment (**Da Silveiraa *et al*., 2002**). Other techniques such as ERIC–PCR and REP–PCR (**Hulton *et al*., 1991**) and random amplification of polymorphic DNA (RAPD)–PCR (**Welsh and McClelland 1990**) have been proposed as alternatives and used to characterize Escherichia coli isolates of avian origin (**Chansiripornchai *et al*., 2001**). Other molecular techniques such as ribotyping and isoenzyme profile have also been used to evaluate the clonality of avian *E. coli* (**Silveira *et al*., 2003**). Some clones are specific to APEC and a small-scale comparison of commensal and pathogenic isolates revealed that 83% of pathogenic strains belong to only five clones, whereas each of the 10 non-pathogenic strains belong to different clones (**White *et al*., 1993**). On the other hand clonal relationships were found for O2:K1 isolates from humans and chickens (**Achtman *et al*., 1986**) and for O78 isolates from humans, cattle, sheep, pigs and chickens (**Cherifi *et al*., 1994**), indicating that these species too might act as a source of infection for chickens. Multiple antimicrobial resistance traits of APEC isolates also show the diversity of APEC, which are often resistant to tetracyclines, chloramphenicol, sulphonamides, amino-glycosides, fluoroquinolones, β-lactam and extended-spectrum β-lactams antibiotics (**Mellata, 2013**). Diversity is also illustrated by a comparative genomic study that has shown genetic variability within O78 serogroup (**Huja, *et al*. 2015**) Resistance to fluoroquinolones was reported within several years of the approval of this class of drugs for use in poultry (**Li, *et al*., 2007**). There is reason for concern that genes conferring resistance to extended-spectrum beta-lactams will emerge in avian pathogenic *Ecoli*strains (**Zhao *et al*., 2001**) and reduce the efficacy of ceftiofur, which is currently used on a limited basis in poultry breeding flocks and hatcheries. In one study, conducted at the University of Georgia, 97 of 100 avian pathogenic E. coli isolates were resistant to streptomycin and sulfonamide and 87% of these multiple antimicrobial resistant strains contained a class 1 integron, intI1, which carried multiple antibiotic resistance genes (**Bass *et al*., 1999**). Multiple antimicrobial resistance traits of avian pathogenic E. coli have also been associated with transmissible R-plasmids (**Wooley *et al*., 1992**).

Pathogenesis and Disease Syndromes of Avian Colibacillosis

APEC are responsible for a considerable number of various diseases at different ages. Neonatal infection of chicks can occur horizontally, from the environment, or vertically, from the hen. A laying hen suffering from *E.coli*-induced oophoritis or salpingitis may infect the internal egg before shell formation. Faecal contamination of the eggshell is possible during the passage of the egg through the cloaca and after laying. The latter possibility is considered as the main route of infection for the egg (**Barnes and Gross 1997**). Before hatching, APEC causes yolk sac infections and embryo mortality. The chick can also be infected during or shortly after hatching. In these cases, retained infected yolk, omphalitis, septicemia and mortality of the young chicks up to an age of three weeks is seen. Broilers may be affected by necrotic dermatitis, also known as cellulitis, characterized by a chronic inflammation of the subcutis on abdomen and thighs (**Barnes and Gross 1997**). Swollen head syndrome (SHS), mainly a problem in broilers, causes oedema of the cranial and periorbital skin. SHS can cause a reduction in egg production of 2 to 3%, and a mortality of 3 to 4% (**Morley and Thomson 1984**). Data on this disease are contradictory (**Picault *et al.*, 1987 and Hafez and Löhren 1990**) considered SHS as a disease caused by avian pneumovirus (APV), usually followed by an opportunistic *E.coli* infection (**Nakamura *et al*., 1998**) however reported that APEC were probably playing a significant part in the disease, but that the

role of APV was not at all clear. This had been confirmed by (**Georgiades *et al*., 2001**), who did not detect APV in any of the flocks affected by SHS during a field study, but instead detected infectious bronchitis virus (IBV), avian adenovirus, avian reovirus, and Newcastle disease virus (NDV), as well as Mycoplasma synoviae and M. gallisepticum (MG). APEC probably do not cause intestinal diseases. Nevertheless, enterotoxigenic *E. coli* (ETEC) are occasionally isolated from poultry suffering from diarrhoea (**Dho-Moulin and Fairbrother 1999**) and diarrhoea was experimentally induced after intramuscular inoculation of APEC (**Zanella *et al.*, 2000**). On the other hand, enteropathogenic *E.coli* (EPEC) were isolated from clinically healthy chickens (**Kariuki *et al*., 2002**). In turkeys, experimentally inoculated EPEC can only cause enteritis in combination with coronavirus (**Guy *et al*., 2000**) Layers as well as broilers may suffer from acute or chronic salpingitis. Salpingitis can be the result of an ascending infection from the cloaca (**Bisgaard and Dam 1981**) or an infection of the left abdominal airsac (**Barnes and Gross 1997**). Salpingitis can lead to the loss of egg-laying capacity (**Dho-Moulin and Fairbrother 1999**). In the case of chronic salpingitis, the oviduct has a yellowish-gray, cheese-like content, with a concentric structure (**Bisgaard and Dam 1981**). In layers, salpingitis can cause egg peritonitis if yolk material has been deposited in the peritoneal cavity, characterised by a sero-fibrinous inflammation of the surrounding tissues (**Barnes and Gross 1997**) Airsacculitis is observed at all ages. The bird is infected by inhalation of dust contaminated with faecal material, which may contain 106 CFU of *E.coli* per gram This aerogenic route of infection is considered as the main origin of systemic colibacillosis or colisepticemia Septicemia also affects chickens of all ages, and is mainly described in broilers. It is the most prevalent form of colibacillosis, characterised by polyserositis (**Goren, 1991**). It causes depression, fever and often high mortality. Although its pathogenesis has not been elucidated, several routes of infection are possible: neonatal infections (**Barnes and Gross1997**).

Diagnosis of Avian Colibacillosis

Colibacillos is suspected based on the clinical features and the typical macroscopic lesions. The diagnosis is obtained by *E.coli* isolation from cardiac blood and affected tissues, like liver, spleen, pericard or bone marrow. Experimentally it was shown that in acute cases, isolation is possible from six hours to three days after infection; in subacute cases, isolation is only possible until seven days after infection (**Gomis *et al.*, 1997**). Selective media like McConkey, eosin-methylene blue or drigalki agar are used for isolation. Further identification of the isolated colonies is based on biochemical reactions (indol production, fermentation of glucose with gas production, presence of ß-galactosidase, absence of hydrogen sulphite production and urease, and the inability to use citrate as a carbon source) (**Dho-Moulien and Fairbrother 1999**).

O-serotyping is a frequently used typing method. An ELISA, based on sonicated *E.coli*, has been developed for detection of antibodies against two important pathogenic serotypes of *E.coli*: O78:K80 and O2:K1(**Leitner *et al*., 1990**). Another ELISA was based on fimbrialantigen (**Bell *et al*., 2002**). Both have limited value because they can only detect homologous APEC types. All currently known virulence-associated factors, detected in strains isolated from colibacillosis lesions, can also be detected in faecal isolates from clinically healthy chickens. For this reason, none of these traits can be used for APEC identification.

Preventive Measures for Controlling Avian Colibacillosis

A first step is the prevention of egg contamination by fumigating them within two hours after lay, and by removing cracked eggs or eggs soiled with faecal material. It is recommended to vent the incubators and hatchers to the outside and to have as few breeder flocks as possible per breeding unit (**Barnes and Gross 1997**). In chicks, contamination with APEC from the environment must be controlled by reduction and control of intestinal infection. This can be achieved using competitive exclusion (CE) (**Kabir, 2009**),i.e., inoculating day-old chicks with normal bacterial flora of healthy adult chickens or a monoculture, for instance of Bacillus subtilis. Birds also need to be protected against pathogens that promote infections with APEC. This is possible by using Mycoplasma-free birds (**Barnes and Gross 1997**) and protecting the birds against mycoplasmas and viral diseases by vaccinations (**Goren, 1991**). Disease introduction must also be avoided bysuitable house infrastructure, the correct use of a transition zone (for changing clothes and shoes, and washing hands), and pest control: rodent faeces are a source of pathogenic *E.coli* (**Barnes and Gross 1997**). The housing climate must be kept optimal for bird density, humidity, ventilation, dust and ammonia (**Dho-Moulin and Fairbrother 1999**). Prophylaxis of colibacillosis is based on strict control of breeding conditions, respect of biosecurity practices and vaccination. However, commercially available vaccines are more or less effective mainly because APEC strains are highly diverse. Vaccines containing killed or attenuated virulent bacteria protect against infection with the homologous strain but it could not be excluded that they are less efficient against heterologous strains (**Sadeyen *et al.* 2015**). Hence,

until recently, vaccination for colibacillosis was not widely practiced due to a large variety of serogroups involved in field outbreaks. A common practice is the use of autogenous vaccines and bacterins that are specifically designed for each particular flock (**Landman *et al.* 2014**). Treatment of colibacillosis relies on antibiotherapy but with the increasing occurrence of multidrug-resistant E. coli isolates, treatment may be unsuccessful.

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