ISSN: 2586-7342 © 2020 KODISA & KJFHC
KJFHC website: http://www.kjfhc.or.kr
doi: http://dx.doi.org/10.13106/kjfhc.2020.vol6.no5.1

Cellulitis in Broiler Chickens

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Received: August 17, 2020. Revised: November 01, 2020. Accepted: November 05, 2020.

Abstract

Cellulitis in broiler chickens is one of the economically important problems that facing the broiler industry due to the presence of the lesion leads to condemnation of part of /or the entire carcasses. Broiler with cellulitis lesions showed lower body weight. Cellulitis was recorded on different body regions including the head, dorsum, thighs, breast, legs, and abdomen. Cellulitis results from the invasion of subcutaneous (s.c.) tissues by bacteria through disruption of skin integrity. Lesions revealed the existence of the characteristic s.c colored exudate varies from yellowish to green, which were either serosanguineous, fibrinous s.c exudate yellowish, greenish or suppurative. Many bacterial isolates including E. coli, Staphylococci, Clostridia, Aeromonas spp., Enterobacter spp., Proteus mirabilis, P. aeruginosa, and Streptococci were isolated from the lesion. Chickens exposed to immunosuppression proved to have a greater probability of developing cellulitis. The condition was experimentally induced by s.c inoculation of 25-day-old broiler chickens with E. coli, S. aureus and clostridia. Usually, bacterial isolates were multidrug-resistant. The usage of Bifidobacterium bifidum or antibiotic with avoiding immunosuppression can reduce lesion and condemnation rate resulted from cellulitis. The objective of this review is to collect different literature written about cellulitis to be available to students, researchers, and veterinarians in poultry practical.

Keywords: Broiler, Cellulitis, Lesions, Signs, Bacterial Causes, Antibacterial Susceptibility, Prevention.

Major classifications: Food Science, Healthy Food

1. Introduction

Cellulitis is a multifactorial disease. Management factors affecting the cellulitis occurrence include scratching, extent of feather cover and immunosuppression (from nutritional or infectious causes). Factors that increase the incidence of broilers scratching each other include feeding programs with insufficient feed space and rodents in the house (Marrow, 2008). Cellulitis is an acute inflammation of the subcutaneous (s.c) tissue with spreading of edematous suppurative exudate, which sometimes extended into the muscles. This review was planned to collect the available different literature and data written in scientific journals, books and cites about cellulitis to be available for students, researchers, and veterinarians in poultry practical.

2. Synonyms

Cellulitis was first reported by Randall et al. (1984) in England. Cellulitis also referred to as necrotic dermatitis, or inflammatory process, infectious process causing accumulation of inflammatory exudate under the abdominal skin of broiler chickens (Gross, 1994; Messier et al., 1993; Morris, 1994).

3. Economic importance

Cellulitis in broiler chickens has become one of the economic problems facing the broiler industry due to the presence of the lesion results in condemnation of part of or the entire carcasses at processing during post-mortem examination in slaughterhouses (Kumor et al., 1998; Morris, 1994). In Canada, where, in 1986, 0.048% of broilers slaughtered were condemned for cellulitis, ten years later, in 1996, the level had reached 0.586% of the carcasses. In 2004, these levels grew to 0.8% which means that approximately 4.7 million birds were lost due to cellulitis (Paniago, 2009). In USA, NASS (2010) data revealed approximately 150 200 metric tons of chicken meat, or 0.88% of the total chicken meat production in the USA, was rejected as a result of carcass condemnation. Cellulitis is the most common causes of condemnation in vegetarian chickens (1.18%), followed by ascites (0.77%), while ascites and cellulitis (0.26% both) were also the most common causes of condemnation in standard chickens (Herenda and Jakel, 1994). Silva and Mota (2003) point to cellulite as the one of the greater causes of carcass rejection in slaughter houses. Cellulite was the main cause of condemnation with 51.20% and 25.27% of all condemnations in poultry carcasses in two slaughterhouses in the southeastern region of the State of Goiás, Brazil (Santana et al., 2008). Weight of cellulitis lesions ranged between 0.9 and 1.7 g, of which 85 % were on the left side of the broiler (Barros et al., 2013). The incidence rate of head cellulitis in 13 flocks was 0.2-1.26%, while rate of rejected carcasses due to cellulitis after de-feathering was 0.9-1.7 percent (Amer et al., 2019).

4. Causes

Cellulitis results from invasion of s.c tissues by bacteria through disruption of the skin integrity (cuts, bites, scratches or other abrasions). Stress factors and immunosuppression helps in increase of incidence in broiler chickens. Injurious behaviors including biting insects, cannibalism, poor litter conditions, foot problems (lameness and arthritis) that lead to a long sitting of birds, systemic infections, and immunodeficiency and are considered as major predisposing factors in avian cellulitis (Bianco et al., 2016; Norton 1997; Peighambari et al., 1995; Rosenberger et al., 1975; Wang et al., 2005).

4.1. Bacterial causes

4.1.1. E. *coli*

Ngeleka et al. (1996) stated that out of 39 *E. coli* isolated from cellulitis where only 38.4% of the isolates were typeable with the standard O antisera, and out of these, isolates the most frequently observed serogroups were O25 and O78. . Sequencing assays for the presence of fim and pap DNA, and for virulence had given variable results but suggested that cellulitis isolates may express F1A and/or other mannose-resistant HA fimbriae different from P and maybe virulent in 1-day-old chickens. Cellulitis in broilers in many cases is caused by *E. coli* clones identical to other pathogenic avian *E. coli* strains. *E. coli* isolates distributed among 6 different serotypes (Derakhshanfar & Ghanbarpour, 2002). de Brito et al. (2002) isolated *E. coli* from cervical cellulitis in broiler chickens, while presence of *E. coli* in 100% of the cellulites lesions (Vieira et al., 2006). *E. coli* isolated from cellulitis lesions in broiler chickens produce a citotoxin, called ECVF (*E. coli* Vacuolating Factor), which causes intense cytoplasm vacuolization in avian cells (Quel, 2013). Thirty four, *E. coli* isolates from carcasses with cellulitis in slaughterhouses were belonged to three main phylogroups; A (55.88%), B1 (5.88%) and D (38.24%) and their virulence genes profile is completely different from that of Colibacillosis in this region (Asadi et al., 2018). *E. coli* isolates from avian cellulitis harbor similar virulence factors with other Colibacillosis lesions (de Brito et al., 2003). Macklin et al. (1999) reported that the detected minor differences could be in the association of specific regional isolates with differing rates of cellulitis; all *E. coli* isolates were able for inducing cellulitis in scratched birds. *E. coli* was isolated in 82.5 % of samples with cellulitis lesions (Barros et al., 2013).

The following *E. coli* serotypes were isolated from field cases: O78:K80 (3x), O2:K56 (2x), O127:K63 (3x), O9:K57 (1x), O140 (2x); two isolates could not be identified. Dermatitis was successful induced by feather follicles infection with *E. coli* O78:K80. Out of 126 condemned carcasses and 272 broilers dead on nine broiler flocks with increased mortality and cellulitis 247 *E. coli* (90.8%) isolates were obtained in pure culture from typical lesions (Poulsen, 2018). *E. coli* in a percentage of 70% was isolated from swollen heads (Shawki et al., 2017). *E. coli* (45.2%) plunging to 9 different O serotypes of *E. coli*; O78 was the most predominant serotype (19%) was isolated from head and body cellulitis (Amer et al., 2019). Amer et al (2020a) molecularly reported that *E. coli* strain O78 isolated from natural cellulitis in chickens harbors iron-acquisition genes iroN and iutA and protectin genes iss. adhesion gene tsh; also, iroN, iss and iutA gen nucleotide sequences accession numbers are MN626681, MN626682, MN626683, respectively.

4.1.2. Staphylococcus species

S. aureus was isolated from broiler carcasses with cellulitis (Derakhshanfar & Ghanbarpour, 2002). An outbreak of chicken vesicular dermatitis due to S. epidermidis was reported by Shimizu et al. (1967). Staphylococcus spp. (33.2%) was isolated from head and body cellulitis, and identified into three coagulase-positive staphylococci with S. aureus as the most prevalent strain (55.1%), and seven coagulase-negative staphylococci in which S. sciuri was the most predominant strain (24.6%) (Amer et al., 2019).

4.1.3. P. aeruginosa

P. aeruginosa was reported to colonize the s.c tissues and induce cellulitis (Peighambari et al., 1995; Gomis et al., 2002). *P. aeruginosa* was isolate from 25% of tested swollen heads samples (Shawki et al., 2017). Pseudomonas was isolated and identified from cellulitis lesions in turkey carcasses at processing (Olkowski et al., 1999) and turkeys with cellulitis (Gomis et al., 2002). *P. aeruginosa* (2.2%) was isolated from head and body cellulitis (Amer et al., 2019).

4.1.4. Streptococcus species

Strep. dysagalactae has been isolated from broilers s.c tissues with cellulitis (Vaillancourt et al., 1992; Peighambari et al., 1995; Gomis et al., 2002). Streptococcus spp. (5.1%), was isolated from head and body cellulitis (Amer et al., 2019).

4.1.5. Actinomyces pyogenes

Actinomyces pyogenes were isolated from broiler carcasses with cellulitis (Derakhshanfar & Ghanbarpour, 2002).

4.1.6. Aeromonas spp

Aeromonas spp. were isolated from 116 (82.9%) of total 140 samples of broiler carcasses and carcass parts. The distribution of the isolates were 94%, 86.6%, 80%, 63.3% in broiler carcass, wing, leg and breast samples, respectively (Sarimehmetoglu & Kuplulu, 2001), also, 47.17% of raw chicken samples were positive for motile Aeromonas spp. and of this 28.30% represented A. hydrophila, and 9.43% of A. sobria (Castro-Escarpulli et al., 2003). A. hydrophila isolates (0.5%) were identified from 400 clinically sick chickens (Dashe e al., 2014). A study from Libya identified 32 Aeromonas isolates from chicken carcasses to the genospecies using molecular techniques and found that A. veroni was the most predominant species (30 isolates) followed by A. caviae and A. hydrophila (Abdullah et al., 2003). Aeromonas spp, reported to colonize the s.c tissues and induce cellulitis (Peighambari et al., 1995; Gomis et al., 2002). Aeromonas was isolated and identified from cellulitis lesions in turkey carcasses at processing (Olkowski et al., 1999). Aeromonas spp. (1.2%) was isolated from head and body cellulitis (Amer et al., 2019).

4.1.7. Enterobacter species

Enterobacter agglomerans was colonized the s.c tissues and induce cellulitis (Gomis et al., 2001; Peighambari et al., 1995). Enterobacter spp. (3.2%) was isolated from head and body cellulitis (Amer et al., 2019).

4.1.8. Proteus vulgaris

Proteus vulgaris was reported from s.c tissues and induce cellulitis (Gomis et al., 2002; Peighambari et al., 1995), Proteus mirabilis was isolated from 40% of swollen heads (Shawki et al., 2017), while 4.4% was isolated from head and body cellulitis by Amer et al. (2019). Proteus was isolated and identified from cellulitis lesions in turkey carcasses at processing (Olkowski et al., 1999) and from turkeys with cellulitis (Gomis et al., 2002).

4.1.9. Clostridial species

C. perfringens and C. septicum were isolated from the affected subcutaneous tissue (Hofacre et al. 1986).

5.2. Complicating factors

5.2.1. Poor litter conditions

Poor litter conditions are more likely to result in an increased incidence of cellulitis due to skin abrasions caused by wet, caked or coarse particles (Marrow, 2008). The non-specific immunity in the skin can play a role. Reduced cellular innate immunity (reduced activity of phagocytes) can be a factor. In southern Ontario, Cellulitis as a count outcome was significantly associated with the hatchery of origin, strain of birds, farm size, type of litter, lighting system, total down time, prevalence of abdominal scratches, *E. coli*-related conditions, ascites, and valgus various deformity (Elfadil et al., 1996). Lesions by cellulite are related to the occurrence of injuries, especially scratches which happen with inappropriate management practices within farming systems (Fallavena, 2003).

5.2.2. Skin trauma

To evaluate the role of trauma to the skin in development of *E. coli* cellulitis and to compare source of isolates in induction of cellulitis in broiler chickens Peighambari et al. (1995) found that no lesion was developed in chickens in with non-traumatized skin and concluded that skin trauma is necessary for initiating disease and that strains of *E. coli* of serotypes epidemiologically associated with cellulitis are highly virulent. Macklin et al. (1999) reported that all *E. coli* isolates were capable of inducing cellulitis in a preponderance of the scratched birds and were not capable for producing cellulitis in not scratched birds.

5.2.3. Flock density

The density of broilers kept on farms may contribute to the outbreak of dermatitis by violation of the skin followed by infection of the injuries. Massage of the infected sites by close contact of birds and insufficient hygiene may support the development of the disease (Glünder, 1990).

5.2.4. Immunosuppressive infection

Gangrenous dermatitis caused by *S. aureus* can be seen following early infectious bursal disease (IBD) virus infection (Rosenberger et al., 1975). Chicks infected early with IBD were more susceptible to gangrenous dermatitis (Rosenberger et al., 1975). Cervantes et al (1988) diagnosed a case of staphylococcal gangrenous dermatitis secondary to IBD in IBD vaccinated broiler flock at 17 days of age. Wang et al. (2005) explored the influence of excessive vaccine doses against both IBDV and chicken anemia virus (CAV) on the development of cellulitis and myositis in broiler chickens in challenged with a mixture of *C. perfringens, C. septicum and S. aureus*, and found that the immunosuppressed chickens showed a greater probability to develop cellulitis and / or myositis. Alves et al. (2007) reported that cellulitis in broiler was associated with IBD bursal lesions and concluded that yellowish injuries under the skin in plaque in the s.c of broiler chickens must be considered as cellulitis and a criterion of the carcass condemnation and favored by the presence of more serious injuries (score 3) in the bursal.

5.2.5. Injected vaccines

Some vaccines induced cellulites as Crespo and McMillan (2008) reported that 10-14 days old replacement chickens were subcutaneously vaccinated in the neck with a *Mycoplasma gallisepticum* (*M. gallisepticum*) bacterin, after few days, 40% of the flock had been developed head cellulitis.

6. Clinical Signs

Clinically, cellulitis can be seen in affected chicken if infection occurs in the head region, and it looks as swollen head syndrome in 5-6 weeks old chickens (Morley and Thomson 1984), while affection of other body sites can be only detected accidentally in post mortem or during inspection in slaughterhouse as no other symptoms are manifested (Bianco et al., 2016). Carcass rejection and condemnation in slaughter houses are mostly increased due to cellulitis (Amer et al., 2019; Santana et al., 2008; Silva & Mota, 2003). Experimentally s.c with 10^8 colony forming units (CFU)/ml) *E. coli* O78 infected 15 days old broiler slowed low feed intake with ruffled feather at the 1st day post infection (dpi) with red swollen skin at site of infection with increase in thick thickness at the 3rd dpi thick red edematous skin and birds with severe lesions were reluctant to move. Mortality started at the 3rd (dpi) was 5% and 10% died in *E. coli* at 5 dpi with total mortality (15%) (Amer et al., 2020b). *S aurous* (10^8 CFU/ml) s.c infected chickens showed 7.5 % mortality while dual half dose infection with *E. coli* and *S aurous* showed 17.5 % % mortality ; treated group showed reduced mortality and lesions (Amer et al., 2020b)

7. Post-mortem lesions

Post-mortem lesions were emphysema, severe enteritis, and a serosanguineous fluid in the s.c tissue of the breast and thighs; there was no evidence of a loss in the integrity of the skin. Lesion of cellulitis can be seen on, dorsum, thighs, breast, legs and abdomen of broiler chickens (Randall et al., 1984; Morris, 1994). Cellulitis lesions characterized by deposition of yellowish fibrin under discolored or thickened skin (Gomis et al., 2000; Randall et al., 1984). Cervantes et al (1988) observed an extensive s.c serosanguineous fluid accumulation over the pectoral muscles, discrete hepatic whitish foci and small, flaccid bursae of Fabricius; *Staph. aureus* was cultured from liver and s.c tissue.

Macroscopically, cellulitis lesions are characterized by accumulation of yellowish fibrin under discolored and/ or thickened skin In cases of skin surface infection, oozing of exudate over the skin "waffle skin", can be seen and most of the infections are commonly seen over thigh muscle, breast, legs, abdomen, head, and neck (Fallavena et al., 2000; Gomis et al., 2000; Randall et al., 1984). The most common lesions were located as diffuse lesions in general body region, followed by the abdomen and the thigh. The lowest incidence was in the back region (Amer et al., 2019). Alves et al. (2007) recorded that well-characterized lesions were generally located in the thigh, back and cloacal area. Extensive s.c serosanguineous fluid accumulation over the pectoral muscles, discrete hepatic whitish foci and small, flaccid bursae of Fabricius in staphylococcal gangrenous dermatitis secondary to IBD (Cervantes et al., 1988). Yellowish injuries under the skin in plaque in the subcutaneous of broiler chickens must be considered as cellulitis (Alves et al., 2007). Skinning of lesions of natural cases revealed the existence of the characteristic yellowish to green subcutaneous (s.c.) exudates which were either serosanguineous, fibrinous s.c. exudate yellowish , greenish or suppurative (Amer et al., 2019). Red swollen thick skin with s.c cerous to caseous exudate over a red edematous muscles of experimentally infected birds (Amer et al., 2020 a & b).

8. Experimentally induction

The condition was experimentally induced by s.c inoculation of 25-day-old broiler chickens with a field isolate of *E. coli* serogroup O78, cellulitis lesion was occurred at 24 hs post-infection in 98% of inoculated birds and *E. coli* was isolated from > 75% of cellulitis lesions (Gomis et al., 1997). Cellulitis and myositis were developed in broiler chickens after challenge with a mixture of *C. perfringens, C. septicum and S. aureus*, following IBD and CAV vaccines (Wang et al., 2005). Amer et al. (2020 a & b) experimentally induced cellulitis in broiler chickens by s.c inoculation of *E. coli O78* and/or *S aureus* isolated from field cases of cellulitis. Yellowish to caseous s.c exudate was seen over the abdomen of the infected bird with thick yellowish red to brawn skin.

9. Antibiotic susceptibility and profile of bacterial isolates from cellulitis

Antibiotics are usually used in poultry farms for therapeutic and growth promoters; however the excessive use of antibiotic still a big threat by inducing and emerging of antibiotic-resistant bacterial strains of both pathogenic and non-pathogenic that could be reach to humans through the food chain (Angulo et al.,, 2005; Apata, 2009; Kariuki, et al., 1999; Nemati et al., 2008; Suleiman et al., 2013).

In Egypt, study reported that *E. coli* had sensitivity ranged from 14.3% to trimethoprim + sulfamethoxazole to 64.3% to clindamycin (Amer et al., 2017). *E. coli* isolates from cellulitis showed high resistance rate to many antibiotics (Amer et al., 2019), as well as the antibiogram profile of Staphylococcus spp. indicated high resistance (Amer et al., 2019).

Osman and Elhariri (2013) recorded that a total of 125 clostridial isolates from broiler flocks in Egypt exhibited resistance to gentamicin, streptomycin, oxolinic acid, lincomycin, erythromycin, and spiramycin with high prevalence of resistance to many antibiotics (Amer et al., 2019).

The isolated Aeromonas strains from chicken carcasses were susceptible to ciprofloxacin, gentamicin and ceftriaxone, while, the isolates showed a significantly higher or complete resistance rate to antibiotics (Ghenghesh et al., 2013, Amer et al., 2019). Enterobacter isolated from chicken was resistant to multiple antibiotics (Amer et al., 2019; Dennison and Morris, 2002; Kilonzo-Nthenge et al., 2008). Proteus isolates recovered from poultry were found to be highly antibiotics (Nemati, 2013), moreover, Proteus mirabilis isolates from celluilits showed different rate of resistance from 77.7% to 11.1% (Amer et al., 2019), antibiogram profile of *P. aeruginosa* showed different degrees of resistance to antibiotics (Amer et al., 2019; Sharma et al. 2017).

Some Streptococcus isolates in Japan showed resistance to tetracycline, doxycycline, and lincomycin (Nomoto et al., 2013) while, in Egypt the antibiogram profile of Streptococcus spp. revealed resistance rats from 9.5% to 85.7% for many antibiotics (Amer et al., 2019).

The miss use of antimicrobial at both sub-therapeutic doses and/or unneeded doses contributes to the emergence of MDR bacteria (Amer et al., 2018; Amer et al., 2019; Ibrahim et al., 2019; Osman & Elhariri, 2013; Xia et al., 2011; Yang et al., 2004).

10. Prevention of cellulitis

Prevention of early infections with infectious bursal disease virus and chicken infectious anemia virus also will help prevent *staphylococcosis* (Santivatr et al., 1981). The number of condemnations for cellulitis and the total number of condemnations at slaughter were significantly reduced in the chickens that received *Bifidobacterium bifidum* (Estrada et al., 2001). Amer et al. (2020b) recorded that administration of Colistin+ doxycycline reduced lesion of s.c injected broiler chickens with *E. coli* and/or *S. auras* isolated from natural cellulitis in chickens.

11. Conclusion

Cellulitis can be considered as a threat for poultry production due to it causes losses due to high condemnation rate in slaughterhouse. The condition can be produced with single or mixed bacterial infections. Difficulties in prevention due to multiple causes and sources of infection, and drug resistance in bacterial causes is a problem in drug use for control. So, good hygiene, avoid causes of skin injury and avoid immunosuppresive are needed to minimize losses due to cellulitis in chickens.

12. Declarations

12.1. Consent for publication

All authors gave their informed consent prior to their inclusion in the study.

12.2. Availability of data

All data collected in this review are included in this published article.

12.3. Competing interests

The authors declare that they have no competing interests.

13. Authors' contributions

All authors are contributed to data collection in addition to participating in writing the review. All authors read and approved the final review.

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