Pathomorphological Investigations on the Incidence of Axial Skeleton Pathology Associated with Posterior Paralysis in Commercial Broiler Chickens

Ivan Dinev

Department of General and Clinical Animal Pathology, Faculty of Veterinary Medicine, Trakia University, 6000 Stara Zagora, Bulgaria

The aim of the current pathomorphological study was to find out the prevalence of various pathological conditions of the axial skeleton associated with posterior paralysis in commercial broiler chickens at a farm over a prolonged period. Cases of clinical posterior paralysis at a commercial broiler chicken farm were registered over a one-year period of research. Of the examined 36 broiler flocks, signs of posterior paralysis were found in a total of 1480 (0.21%) chickens from 23 flocks. In 22 of these flocks, the chickens with posterior paralysis were recorded, marked, and put in an isolation premise where they were kept with access to food and water until the respective flocks were to be processed. In one of the flocks, posterior paralysis was found in 71 chickens at the age of 34 days in association with an outbreak of femoral head necrosis (FHN), arthritis, and osteomyelitis, which were also isolated. During the period of isolation, 13 of these chickens died, and the surviving 58 were processing at a processing plant.

A total of 151 vertebral columns were randomly collected from 6 isolated chicken carcasses from each of the 23 flocks at the processing plant, which had exhibited posterior paralysis, as well as following autopsy of the 13 chickens that had died from the isolation premise of the flock where simultaneous occurrence of FHN, arthritis, and osteomyelitis was observed. The samples were submitted to gross, histological, radiography, and microbiological examinations. Spondylolisthesis (64; 42.3%), followed by cases of spondylosis with ankylosis, osteosclerosis and fractures (54; 35.8%), vertebral osteomyelitis (19; 12.6%), and osteochondrosis with scoliosis and fractures (14; 9.3%) were the most prevalent conditions.

Key words: axial skeleton, broiler chickens, pathology, posterior paralysis

Introduction

Most of available data are on the prevalence of lameness in broiler chickens and broiler breeders, associated with pathology of the hind limb (Duff and Randal 1987; McNamee et al., 1999; Bradshaw et al., 2002). These include a number of cases related to deficiency or infectious etiology, as well as specific forms of rickets, femoral head necrosis, rupture of the gastrocnemius tendon (Dinev, 2008, 2009, 2012). Data on axial skeleton abnormalities, mostly spondylolisthesis and scoliosis, which could be asymptomatic, can be found in separate reports. Howlett and Wood (1984) examined 68 young broilers, which were clinically healthy to discover scoliosis and/or spondylolisthesis in 32 birds. Riddell (1973) described clinical findings in broilers with spondylolisthesis and spinal cord compression, which were reared until sexual maturity. Osteoarthritis have been reported in the spines of layer hens (Yamasaki and Itakura, 1983). Duff (1988) examined the prevalence of vertebral abnormalities in adult (over 60 weeks of age) male broiler breeders, which had not exhibited clinical symptoms. The data from these studies showed occurrences of scoliosis, angular deformity of the spinal canal and joint osteochondrosis in approximately 60% of the birds. Cases of spondylitis in broiler chickens were described in association with infectious agents such as Staphylococcus aureus (Carnaghan, 1966), Enterococcus cecorum (Aziz and Barnes, 2007; Stalker et al., 2010), Aspergillus fumigatus (van Veen et al., 1999). Spondylosis of enzootic origin was described in turkeys (Friedman et al., 1988), as well as a single case of cervical spondylosis in a black swan (Hultgren et al., 1987).

The aim of the current pathomorphological study was to find out the prevalence of various pathological conditions of
the axial skeleton associated with posterior paralysis in commercial broiler chickens at a farm over a prolonged period.

Material and Methods

Over a one-year period, cases of clinical posterior paralysis at a commercial broiler chicken farm were recorded. Broilers of the Ross 308 hybrid were reared. The yearly production cycle was 696,000 birds. The studies included a total of 36 broiler flocks, 24 of which consisted of 20,000 chickens each (during the winter-spring and autumn seasons) and 12 of 18,000 birds each (during the summer season). The birds received diets as recommended by Ross technology. The same immunoprophylaxis programme was used for both the broilers and the parent flocks.

Signs of posterior paralysis were observed in a total of 23 flocks, 8 of which during the summer season and 15 during the other seasons. In all flocks, the chickens with posterior paralysis were recorded, marked, and separated into an isolation facility with access to food and water until the respective flocks were to be processed. The sex of chickens with clinical signs was not recorded. In one of the flocks at the age of 34 days, during the summer season, posterior paralysis was found in 71 chickens, in association with an outbreak of femoral head necrosis (FHN), arthritis, and osteomyelitis, which were also isolated. During the period of isolation, 13 of these chickens died, and the surviving 58 were processed at the processing plant. Due to the upcoming processing of the flock (on the 38th day), no drug therapy was undertaken. The isolation of chickens which have shown typical clinical symptoms was undertaken in order to track the survival in such conditions and the influence of the disease on the state of the affected chickens.

Gross Anatomy Study

Samples from vertebral columns were randomly collected at the processing plant from 6 carcasses of the isolated chickens from each of the 23 flocks, which had exhibited posterior paralysis, as well as following autopsy of the 13 chickens that had died from the flock where simultaneous occurrence of FHN, arthritis, and osteomyelitis was observed (a total of 151 samples). The entire vertebral column, following separation of the associated bones (shoulders, ribs and pelvic bones), was fixed in 10% neutral formalin for 48–72 hours. It was then demineralized in 6% nitric acid for 72 hours. The spinal canal was exposed through a longitudinal incision along the entire vertebral column.

Radiography

Before the demineralization process, all vertebral columns separated from the selected carcasses of the 23 flocks at the slaughterhouse were radiographed in lateral and ventrodorsal views.

Histopathological Study

Samples from areas with macroscopic lesions at the border with intact part of the vertebral column and the spinal cord were collected for histopathological study. The fixed and demineralized tissues were processed using conventional histological techniques and embedded in paraffin. Five μm sections were stained with haematoxylin and eosin (H/E) as well as according to Gram for bacteria (Brown and Hopps, 1973).

Bacteriological Study

Five samples of femoral bone marrow were collected from selected carcasses of each flock at the processing plant as well as from the 13 dead chickens from the flock, with simultaneous occurrence of FHN, arthritis, and osteomyelitis for bacteriological examination, using the respective methods for identification of enterobacteria and Gram positive cocci.

Results

Clinically, signs of posterior paralysis were observed in 23 out of the 36 examined broiler flocks in a total of 1480 (0.21%) chickens. There were no clinical signs in the other 13 flocks. Typical clinical findings were ataxia and sitting on the tarsometatarsal joint with legs stretched forward (sitting dog pose), as well as some chickens lying in lateral recumbency (Fig. 1). In attempts to move, they used their wings to support themselves, and usually fell backwards. Despite the various extent of clinical posterior paralysis, the chickens were in good condition until they were sent for processing.

Gross anatomy studies were carried out after longitudinal median incisions of previously demineralized vertebral column samples, which allowed for the opening of the spinal canal and visualization of the spinal cord.

Based on radiography findings and established macroscopic alterations in all 151 vertebral samples, the lesions were categorized (Table 1). Most prevalent were the cases of spondylolisthesis (64 or 42.3%), followed by spondylosis, ankylosis and osteosclerosis with fractures (54 or 35.8%), vertebral osteomyelitis (19 or 12.6%) and osteochondrosis with scoliosis and fractures (14 or 9.3%).

<table>
<thead>
<tr>
<th>Lesion type</th>
<th>Total number of lesions found</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spondylolisthesis</td>
<td>64 (42.3%)</td>
</tr>
<tr>
<td>Spondylosis, ankylosis and osteosclerosis with fractures</td>
<td>54 (35.8%)</td>
</tr>
<tr>
<td>Vertebral osteomyelitis</td>
<td>19 (12.6%)</td>
</tr>
<tr>
<td>Osteochondrosis with scoliosis and fractures</td>
<td>14 (9.3%)</td>
</tr>
</tbody>
</table>

Total number of samples 151 (100.0%)
Examination of vertebral columns with spondylolisthesis revealed various degrees of ventral dislocations of the fourth thoracic vertebra (T4). With its posterior end lifting the fifth thoracic vertebra (T5). Consequently to dislocation there were kyphotic angulation of the spinal canal bottom and various degrees of spinal cord compression in that area (Fig. 2).

In the cases of spondylosis, the same vertebrae (T4 and T5) were affected, with their colour being paler and distinguishable among the adjacent intact vertebrae. In over ¾ of spondylosis cases, T4 and T5 were located at the same position as in cases of spondylolisthesis. Macroscopically, degenerative necrobiotic changes, ankylosis and fractures were seen.

In the 19 examined vertebral column samples (13 procured after autopsy of carcasses from the isolator and 6 coming from the processing plant), in the chickens from the flock with simultaneous outbreaks of FHN, arthritis and osteomyelitis, mainly the caudal parts of T3, T4 and T5 were affected at a time. Lesions were also observed on the cranioventral...

Fig. 1. A usual clinical finding. Sitting on tarsometatarsal joints with legs stretched forwards (sitting dog posture) due to posterior paralysis, bar=3 cm.

Fig. 2. Spondylolisthesis. Ventral dislocation of T4, whose posterior end lifts T5, resulting in kyphotic angulation of the spinal canal bottom and spinal cord compression in this area. Upper left corner – a fragment. Right bottom corner – compressed spinal cord outside (arrow), bar=3 cm.

Fig. 3. Vertebral osteomyelitis. The sagittal cross section reveals a dorsoventral spread of the inflammatory swelling with dorsal shift and compression of overlying spinal cord in the region of T4, T5 and L1, bar=2 cm.

Fig. 4. Osteochondrosis (region T4–T5) characterized by a plug of cartilage in the ventral aspect of a thoracic vertebra (arrow). Articular cartilage at the junction of T4 and T5 was necrotic and the ventral intervertebral ligament was thickened, bar=2 cm.
part of the first lumbar vertebra (L1). The sagittal cross section revealed dorsoventral spreading of inflammatory swelling with a dorsal shift and compression of the overlying spinal cord (Fig. 3). Some of the lesions were surrounded by partial or complete perifocal fibrous reaction. No other pathological conditions related to the axial skeleton were found in these flocks. In 14 (9.3%) cases the sagittal cross section revealed lesions of osteochondrosis and compression of the spinal cord by the proliferous cartilage (Fig. 4). Lateral radiographs were valuable in the cases of spondylolisthesis and spondylosis, ankylosis and osteosclerosis with fractures. With spondylolisthesis, there were various degrees of vertebral dislocation of the free T4 between the notarium and sinsacrum. Intervertebral spaces were clear (Fig. 5, Plate A). In the cases of spondylosis, T4 and T5 were fused together, without a visible intervertebral space and with distinct radiographic density, ankylosis, (Fig. 5, Plate B). The location of spondylosis was radiographically visible as increased radiodensity of areas identified during the macroscopic examination.

Ventrodorsal radiography in 4 cases (9.3%) of osteochondrosis also confirmed lesions of scoliosis and partial fractures. Radiographs revealed that the scoliotic curvature was, in most cases, a result of abnormal angulation between the caudal notarium, T4, and the cranial sinsacrum.

Histopathologically, cases of spondylolisthesis exhibited a marked T4 displacement, distortion of the vertebra and the articular facets. The compression of the spinal cord was particularly expressed in the area of the white brain substance above the articulation between T4 and T5. Degenerative damage of the spinal cord and the vertebral bodies were not found in the birds with spondylolisthesis. In spondylosis cases there were lesions of necrobiosis at the caudal end of T4 and the cranial end of T5 and fractures in the intervertebral space. Microscopically, in some of the spondylosis cases in the T4-T5 area an ankylosis was established. Non-inflammatory lesions of necrobiosis and haemorrhages in the synovial cartilage could be found.

In histological samples of chickens from the flock with outbreaks of FHN, arthritis and osteomyelitis, lesions specific for vertebral osteomyelitis were found. The infection has spread from the bone into the intervertebral joint causing necrosis, producing purulent debris and vertebral tissue protruding into the cord (Fig. 6, Plate A). As a morphological expression of inflammation, there were epidural pseudocysts formed both dorsally and ventrally of the spinal canal, mostly in the T4–T5 area and sometimes in the adjacent posterior T5 and anterior L1 areas. The pseudocystic formations were filled with serous bloody fluid and compressed the spinal cord dorsoventrally (Fig. 6, Plate B). Pseudocystic formations were sometimes also found among the compressed spinal cord substance in the presence of a slight inflammatory cell reaction (spondylomyelitis), (Fig. 6, Plate C). Necrotic lesions affected completely the vertebral bodies of T4 and T5, and sometimes partially the caudoventral part of T3. In some areas the bone tissue was missing (osteolysis) and was replaced by overgrown fibrous tissue with small bony islands and numerous blood vessels within. No microorganisms were detected in the Gram-stained cuts. In the cases of osteochondrosis and scoliosis, angular deformation of the notarium and sinsacrum were easily found histologically, accompanied by degenerative injuries of T4. In these cases a usual finding was the articular osteochondrosis between notarium–T4–sinsacrum caused impingement of the cord (Fig. 6, Plate D).

The Gram-stained histological sections did not reveal the presence of microorganisms in any of the cases.

Bacteriologically, of all examined bone marrow samples, E. Coli O78 isolates were found only in those collected from chickens originating from the flock with spondylitis, simultaneously with outbreak of FHN, arthritis, and osteomyelitis.

Discussion

The results of this study on broiler chickens with clinical signs of posterior paralysis definitively proved their association with various pathological conditions of the axial skeleton which impinge upon the spinal cord. Foremost among these conditions in our investigation was the spondylolisthesis, present in nearly half (64 or 42.3%) of the examined samples. A possible explanation for this high prevalence could be found in the anatomical structure of the vertebral column in this bird species. It is known that most
thoracic and lumbar-sacral vertebrae undergo ankylosis and form 2 immobile units, notarium and saccrum (Baumel and Witmer, 1993; Salomon and Krautwald-Junghans, 2008), a process which normally ends at the onset of sexual maturity (Riggins et al., 1977). In relation to that, it could be assumed that the remaining freely moving T4 and its adjacent vertebrae would most likely exhibit anomalies during the period of skeletal immaturity (Osbaldiston and Wise, 1967; Kelly 1971; Riddell and Howell, 1972; McCaskey et al., 1982; Riddell et al., 1983). The results of our studies on spondylolisthesis have established a dislocation of T4 in all cases. This condition corresponds with cases described by some authors using one nomenclature (McLelland, 1990; Julian, 2005; Crespo and Shivaprasad, 2008) and differs from the results of others using different nomenclature, noting that the affected vertebra was T6 (Riddell and Howell, 1972; Dinev: Axial Skeleton Pathology in Broiler Chickens 287

Fig. 6. Plate A: Vertebral tissue protruding into the cord (arrow 1) resulting in various extent of spinal cord compression (SC; arrow 2) in a vertebral osteomyelitis case. Degenerative and necrobiotic lesions and haemorrhages in the synovial cartilage and compressed spinal cord area, H/E, bar=100 μm. Plate B: Epidural pseudocysts (PC) in cases of vertebral osteomyelitis, both dorsally and ventrally to the spinal canal mainly in the T2-T5 region, filled with serous bloody fluid, resulting in dorsoventral spinal cord compression (SC and arrows), H/E, bar=40 μm. Plate C: Sometimes, pseudocystic formations (PC) were detected among the compression spinal cord substance (SC) in the presence of weak inflammatory cell reactions (arrows) in cases of vertebral osteomyelitis, H/E, bar=25 μm. Plate D: Osteochondrosis (region T4-T5) caused impingement (C) of the cord (SC) by a cartilaginous protrusion (P) including haematoma (H). Necrotic eosinophilic debris (N) of the physeal cartilage, H/E, bar=40 μm.
Observed macroscopic lesions did not differ by location from those of FHN, arthritis, and osteomyelitis in these flocks. The observed clinical signs of posterior paralysis in the examined cases of vertebral osteomyelitis in one of the 23 flocks with such clinical expression could be related to the formed epidural pseudocysts, detected histologically, which compressed the spinal cord in the interspace between T2 and T5. In our research, vertebral osteomyelitis was etiologically related to E. coli infection and the simultaneous occurrence of FHN, arthritis, and osteomyelitis in these flocks. The observed macroscopic lesions did not differ by location from the case of spondylitis associated with Enterococcus cecorum (Stalker et al., 2010; Martin et al., 2011), yet differed from the report of spondylitis associated with Aspergillus fumi-gatus, in which case cervical vertebrae were also affected apart the thoracic vertebrae (van Veen et al., 1999).

The cases of osteochondrosis and simultaneously confirmed through radiography scoliosis and partial fractures 14 (9.3%) had the lowest prevalence among the pathological conditions of the axial skeleton, according to our research. In these cases we consider that the conditions of scoliosis and the partial fractures are caused by primarily manifested osteochondrosis.

The observed clinical signs of posterior paralysis are sometimes hard to distinguish from these described in tibial dyschondroplasia (Leach and Monsonego-Ornan, 2007), but the type of lesions is different.

Summarizing the results of our research, we think that most of the established pathological conditions (spondylolisthesis, spondylosis with ankylosis and osteochondrosis with fractures), which are manifested by posterior paralysis, are related to the anatomical features and the level of maturity of the axial skeleton among broiler chickens, while the observed vertebral osteomyelitis was spontaneous with proven etiology.

Acknowledgments

The author, Ivan Dinev, has applied for a grant, supporting publishing in peer-reviewed journals with impact factor – PROJECT BG051PO0013-05-001 “Science and Business”, financed by Operational Programme “Human Resourses”; funded by the European Social Fund, the European Union.

Special thanks to I. Naidenov, DVM, Regional Veterinary Station, Rousse, for the performed bacteriological tests; to Assoc. Prof. M. Paskalev, PhD, DVM, Department of Veterinary Surgery, FVM, Trakia University, Stara Zagora for the exceptionally courteous assistance in radiography; to the poultry farm Apetit Ltd., Stara Zagora for giving us the opportunity to carry out field research and the provided carcass material.

References


