Review Article

Review - Gout In Chicken

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Abstract |Chicken is more prone to gout due to uricotelic mechanism for excretion of nitrogenous waste and lack the enzyme uricase, which converts uric acid to less harmful substances. Uric acid itself is not toxic but precipitated crystals can cause severe mechanical damage to tissues like kidneys, heart, lungs, intestine (visceral gout) and also in the joints (articular gout). Gout is a multifactorial metaboic disease which involves infectious agents, nutritional factors and managemental prcatices. Infectious agents include Nephropathic Infectious Bronchitis Virus (IBV), Avian Nephritis Virus (ANV), Chicken Astrovirus (CAstV) and nutritional factors like high dietary calcium (>2%), high crude protein (> 30%), Hypovitaminosis A, Hypervitaminosis D3, dehydration, high sodium carbonate, Copper sulfate, mycotoxins in feed causes renal failure leads to gout. The managemental practices involves high brooding temperature thereby reducing the water intake and hence increasing chances of development of gout. In addition, products used on a routine basis and result into toxicity includes antibiotics, anticoccidials, manufactured chemicals, and pesticides can also induce gout in poultry. Clinical signs include decreased feed and water intake, lethargy, ruffled feathers, weight loss and abnormal droppings. Clinically, the body fluid reveals increase in TEC, TLC, Hb and PCV and decreased alanine transaminase (ALT), aspartate aminotransferase (AST), alkaline phosphatases (ALP), serum total proteins, serum albumin and glutathione stimulating hormone (GSH). Grossly, chalky white deposits of urate crystals on the serosal surface of pericardium, liver, intestines, air sacs, kidneys and ureters. Microscopically, tissue sections show urate crystal deposition in parenchyma of the organs along with infiltration of inflammatory cells. Incorporation of low protein diets, jaggery mixed water, supplementation of B complex and electrolytes helps in the control of gout.

Keywords | Gout, Poultry, Pathological lesions, Treatment

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INTRODUCTION

Gout is a common metabolic disorder that results in abnormal accumulation of urates in domestic birds (Ali and Sultana, 2012). In case of gout, the blood levels of uric acid can be as high as 44 mg/100ml as compared to 5-7mg/100ml in a normal bird. Kidney is one of the vital organs with many functions in birds that affected by some diseases and disorder and the most important of them is gout syndrome. The primary function of the kidney is to maintain the chemical composition of body fluids (blood). It serves a variety of other functions in the body like removal of metabolic waste and toxic products; conserving fluids and vital electrolytes; regulation of blood volume and production of hormones that regulate blood pressure and production of red blood cells. When renal function stops, uric acid, normally excreted by the kidney in the urine, is then deposited any place that blood is circulated (Alice mitchell, 2015). Hyperuricemia is a central risk factor for gout and increases the risk for other chronic diseases, including cardiometabolic disease, kidney disease, and hypertension (Hong et al., 2020). Hyperuricemia is the outcome of a combination of an endogenous purine metabolism disorder and an exogenous environmental disruption (Dalbeth, 2016). The high levels of uric acid subsequently precipitates as monosodium/calcium urate crystals in a variety of locations, particularly in the kidneys and on the serous membranes of the liver, heart, air sacs and joints.

These crystals, being insoluble in tissue fluids and having sharp ends, cause physical damage to the tissues leading to a cascading inflammatory reaction However, other mammals, such as rats, mice, and rabbits, contain uricase and can metabolize urate to allantoin, which is soluble in water and easy to excrete (Lee et al., 2013). Chickens affected by renal damage can continue to be productive until less than one third of their normal kidney mass remains functional. Gout is not a single disease entity, but rather the result of kidney damage from a number of potential causes, which can be infectious, nutritional, toxic or possibly a combination of factors. The disturbed balance of the minerals like calcium and phosphorous in diet can result in various pathological conditions including renal failure and development of gout in chicken. High dietary calcium concentration (>2%) causes nephrosis and visceral gout in broilers. Mineral imbalance, particularly of calcium and phosphorus, is one of such problems responsible for economic losses to farm holders, who often formulate the poultry rations themselves. Some infectious agents like IBV, CAstV and ANV along with lack of proper managemental practices causes renal failure leads to gout. Although gout has been recognised for some time as a cause of excessive pullet and layer mortality, it continues to be a diagnostic challenge. Birds can be in full production and exhibit few external symptoms until shortly before death (Alice mitchell, 2015).

INCIDENCE OF GOUT

Season

The highest prevalence of this disease was recorded during colder months followed by summer and lowest in rainy season (Srivastava et al., 2002; Jana et al., 2008; Yadav et al., 2020; Lakkawar et al., 2018; Panigrahi, 2017). There is also excess formation and decreased dissolution of uric acid at colder temperature leads to cold stress and results in high mortality. Higher prevalence of gout in rainy season than summer season could be ascribed to poor hygienic conditions prevailing during rainy season (Sayed, 2001).

Age

Age wise susceptibility and mortality due to visceral gout is highest among young chicks in comparison to adult birds (Mallinson et al., 1984; Wideman, 1988; Wideman et al., 1994; Jana et al., 2008; Singh et al., 2013; Panigrahi, 2017, Yadav et al., 2020). When pullets sexually mature, they are placed on higher-calcium diets to meet the demands of egg production. If the kidneys were previously damaged, they may no longer function normally with the higher level of calcium excretion, and the result is likely to be gout (Alice mitchell, 2015).

CAUSES

Gout is one of the conditions affecting poultry and was initially thought to be a nutritional problem. However, with the advent of science and development of diagnostic assays, viruses have been detected from gout cases (Panigrahi, 2017). Gout is a multifcatorial metabolic disease result of kidney damage from any of a number of potential causes (Alice mitchell, 2015). Raised levels of uric acid in the blood (hyperuricaemia), which may be due either to over production of uric acid or impaired destruction of uric acid because of deficient enzymes systems or to its decreased excretion, either due to impaired filtration or altered excretion in the tubules as may occur in drug therapy like aspirin, mercuric salts etc. (Ali and Sultana, 2012).

Nutritional Causes

One of the important factors for the incidence of visceral gout was dietary calcium percentage in the broiler starter ration. Different standard specifications have been given by Bureau of Indian Standards (BIS, 1992) as maximum inclusion of calcium is 1.2 per cent, whereas Leeson and Summers (2008) had mentioned 1 per cent inclusion of calcium as most appropriate. Inclusion of high calcium(>2%) in broilers diet lead to some disorders in the physiologic process of kidneys consequently resulting in urates depositions on serous surfaces of viscera especially kidneys which are the signs of gout syndrome that causes huge mortality among flocks (Pater et al., 2007; Feizi et al., 2011). An increase in dietary protein can cause an increase in kidney size and glomerular filtrate rate (GFR), with subsequent glomerular injury, accumulation of mesangial deposits, and eventually results in glomerulosclerosis (Khan and Alden, 2001; Pater et al., 2007; Singh et al., 2013; Hong et al., 2020). Based on recommendations of BIS 2007, the optimum crude protein levels are 22 and 20 per cent for broiler starter and broiler finisher ration respectively. Healthy kidneys are not affected by high dietary protein levels. Nevertheless, in case of pre-existing kidney damage, feed containing more than 30 per cent of crude protein can be dangerous that leads to excessive uric acid production which further worsens the kidney function. Adulteration of protein supplements with urea increases the nitrogenous component, further enhancing the uric acid production. This coupled with kidney damage can lead to gout. (Alice and mitchell, 2015).

Minerals

Calcium: Phosphorus ratio - Excess dietary calcium with low available phosphorus results in precipitation of calcium-sodium-urate crystals. Excess dietary calcium fed to immature pullets over a period of time will result in kidney damage that may lead to gout. Phosphorus has been shown to partially protect the kidney against calcium induced damage and also it acts as a urinary acidifier and helps to prevent stones from forming in the kidney. But marginally low available phosphorus in rearing diets has been asso-

ciated with higher gout incidence (Alice mitchell, 2015). The kidney performed its normal physiological functions only when calcium and phosphorus are maintained in a specific ratio of 2:1 that necessitates maintenance of different physiological mechanisms including secretions, excretions and resorption etc. An imbalance of these minerals in diet can result in renal failure and development of gout in chicken (Ali and sultana, 2012). Outbreak of gout attributed to disproportionate Ca: P ratio (3.5: 1) and 16.39% crude protein in the feed has been reported (Mir et al., 2005; Guo et al., 2005). Higher levels of dietary proteins cause excess uric acid production and nephropathy while higher dietary levels of calcium and low levels of phosphorus lead to increased retention and decreased excretion of uric acid (Mir et al., 2005).

Sodium: Sodium intoxication puts extra stress on kidneys. Hard water with higher salt content is also a load on kidneys. Sodium bicarbonate is sometimes used to improve egg shell quality or combat the effects of heat stress. (Poultry gout, growel agrovet private limited, 2016). Sodium bicarbonate can contribute to gout by making the urine more alkaline, which, with high levels of calcium, is an ideal medium for the formation of kidney stones. (Alice mitchell, 2015; Ali et al., 2018; Ejaz et al., 2005).

Sulphates: Decreased calcium resorption causing excessive calcium secretion through urine favours gout.

Dehydration

Dehydration due to water deprivation is also a common cause for visceral deposition of urates (Onderka, 1987). Managemental causes like Improper brooding temperature in which too high or too low brooding temperature, heats up or chills the water respectively – thereby reducing the water intake and hence increasing chances of development of gout. Inadequate number of waterer/nipples, Improper height of waterers, Water withdrawal during vaccination, too low water pH – leads to water rejection by poultry or irritates the epithelium. Chicks held for a long in hatchery or transported for a long distance without water leads to renal failure and results in gout (Alice mitchell, 2015).

Vitamins

High levels of vitamin D3 increases calcium absorption from the gut which can favour further formation and deposition of urate crystals. Prolonged vitamin A deficiency causes sloughing of tubular epithelium and subsequent blockade resulting in accumulation of urates in the kidney (Alice mitchell, 2015).

Infectious causes

Among the infectious causes, the viral pathogens like Avian Nephritis Virus (ANV), Nephropathic Infectious Bronchitis Virus (IBV) and Chicken Astrovirus (CAstV)(Bulbule NR et al., 2013) are listed, but the IBV may lead to permanent kidney damage with high mortality (Singh et al., 2010). The most prevalent strain of IBV was Masachusette strain; its outbreaks caused visceral gout and nephrosis in commercial young broiler chicken and widely spread throughout the country in a short period, therefore caused huge economic losses (Gaba et al., 2010; Ali and sultana, 2012; Panigrahi, 2017). The disease, when vertically transmitted, affects the kidney of progeny leading to gout in young chickens (Alice mitchell, 2015).

Miscellaneous causes

There are several mycotoxins that are nephrotoxic and/or hepatotoxic in laying hens, including citrinin, ochratoxin A, oosporein, and deoxynivalenol (DON) cause damage to kidney and liver thereby uric acid excretion is reduced resulting in accumulation of uric acid in the body.(Guo et al., 2005; Sid and Fettah, 2011; Bulbule et al., 2013; Alice mitchell, 2015). *Metabolic cause like* Ascites – Hypoxic conditions increases the production of uric acid. Ascites in initial stages can lead to symptoms of gout (Alice mitchell, 2015). Antibiotics like gentamycin, sulphonamides and nitrofurosones are known to cause renal damage especially in young chicks. The drugs which get excreted through the kidneys have their own imbalancing effect on pH and renal metabolism. Disinfectants like phenol and cresol if used erroneously cause residual toxicity. Chemicals like copper sulphate used in water results in water refusal, dehydration and gout (Yadav et al., 2020). Anticoccidials, manufactured chemicals, and pesticides can also induce gout in poultry.

TYPES OF GOUT

There are two major forms of gout which are differentiated by the sites of uric acid deposition- visceral and articular gout. In both forms, deposits consist of needle shaped crystals called tophi.

Visceral gout

A condition in which white uric acid or urate crystals deposits are seen in soft tissues of various organs in body. Visceral gout is considered to be the acute form of disease causing huge mortality characterized by the urate deposits on serosal surfaces, most often in the liver, kidney, pericardium, heart and air sacs. Visceral gout is more common in broilers as young as 2-3 days old. In layers, pullets above 14 weeks are more likely to be affected. Whenever there is kidney damage, excretion of uric acid gets affected and uric acid starts accumulating in the blood and later in tissues (Banday et al., 2009).

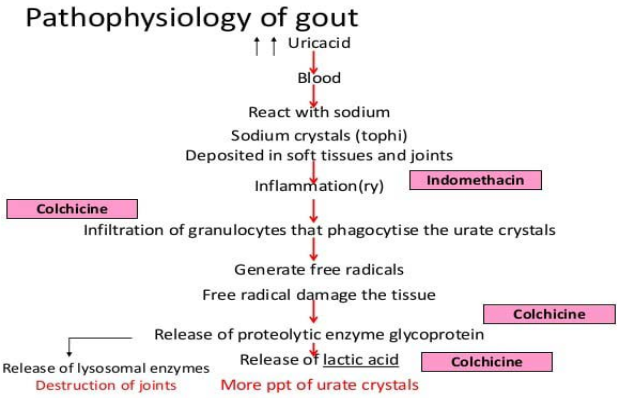
Articular gout

It is a chronic form of the disease and is less common

which occurs when uric acid and urates are deposited in the ligaments and tendons, but more commonly in the legs or synovial fluid and synovial membranes of toes and wing joints, and incite a chronic granulomatous reaction to urate crystals (tophi). Deposits of MSU can also be detected around the joints (periarticular gout). The joints become swollen, red, tender swell, and warm to touch. This condition is rarely seen and usually a chronic condition. Kidneys are generally normal and may become abnormal with white urate deposit if bird gets dehydrated. A bird with articular gout prefers to sit on a flat surface instead of perching because of the pains. If forced to walk, the bird becomes noisy due to discomfort. It may also be depressed and dehydrated, with greenish diarrhoea. In addition, the bird will look dull, its feathers ruffled and the vent moist. It is unusual for gout to affect more than one or two joints at a time. When gout crystals form in the feet, they usually also form in the wing. The most commonly affect wing joint is the birds wrist (carpus) (Ali and sultana, 2012).

Pathophysiology of gout

Gout occurs due to decrease in kidney function to the point where uric acid (a nitrogenous waste) accumulates in the blood and body fluids. The pathogenesis of visceral gout is not completely understood but generally is considered to be the acute form of disease causing huge mortality characterized by the urate deposits on serosal surfaces, most often in the heart, kidney, liver, and air sacs as reported by Mc Gavin and Zachary (2007), Saif (2008), Sandhyarani et al. (2019). The damaged kidneys appear atrophied or missing portions of kidney lobes with whitish gritty material in kidneys and enlarged ureters. Compensatory enlargement of remaining part of normal kidney can be observed in an attempt to maintain adequate renal function (Siller et al., 1981; Goryo et al., 1984; Jones et al., 1998; Banday et al., 2009). Birds are uricotelic, that is, in them , the waste product of protein metabolism is mainly in the form of uric acid. This is because they lack the enzyme uricase, which converts uric acid into allantoin. Moreover uric acid is water insoluble. Therefore any injury or damage to bird's kidney, from whatever cause, interferes with eliminaton of uric acid, which then accumulates in the blood (hyperuricaemia) and leads to visceral gout. On the other hand, mammals are ureotelic where the waste product of protein metabolism is in the form of urea which is water soluble, and therefore mammals are not prone to gout like birds. Some times precipitated monosodium urate crystals in turn, triggers a chain of events that end in joint injury. Once crystals are deposited into a joint, they can be released into the joint space and initiate an inflammatory cascade causing acute gouty arthritis. The released urate crystals are chemotactic and also activate complement which results in generation of C3a and C5a which induce accumulation of neutrophils and macrophages in the joints and synovial membranes. Phagocytosis of crystals causes release of toxic free radicals and leukotrienes, particularly B4. Death of the neutrophils releases destructive lysosomal enzymes. Macrophages also participate in joint injury. After ingestion of urate crystals, macrophages secrete a variety of pro-inflammatory mediators, such as inteleukin-1, IL-6, IL-8 and tumour necrosis factor (TNF). These not only intensify the inflammatory response, but also activate synovial cells and cartilage cells to release proteases that causes the tissue injury and develops acute arthritis (JL VEGAD). These acute flares resolve, but the crystals remain in the joint. The way to ultimately correct the underlying metabolic problem of hyperuricemia and the crystal deposition is to lower the serum urate level and dissolve the crystal deposits. This will stop both the acute attacks and the progressive joint damage (Ali and sultana, 2012).



Clinical Symptoms

The ante-mortem clinical manifestation of affected chicks are dullness, dehydration, ruffled feathers, seggregatory behavior, restlessness, moist vent with whitish pasty droppings, difficulty in movement and standing on legs, painful joints and may continually shift weight from one foot to the other and have a shuffling gait. The bird may be unable to perch, spending most of the time on the floor of the cage. If the wings are affected, the bird may be unable to fly. Birds often have reddened, swollen feet that progress to blisters and sores, joint pain and joint immobility that urate deposits cause. At postmortem, all the carcasses were emaciated and dehydrated with moderate enlargement of hock and phalangeal joints. Other signs include decreased appetite, lethargy, general debility and weight loss, feather plucking, dull plumage and Self-trauma, abnormal droppings, chalky urates in their stool and change in temperament (Ali and sultana, 2012, Patel et al., 2014, Akter and Sarkar, 2015).

Clinical Pathology

The birds affected with gout have a significant increase in serum uric acid (>5-7mg/100ml) and serum creatinine

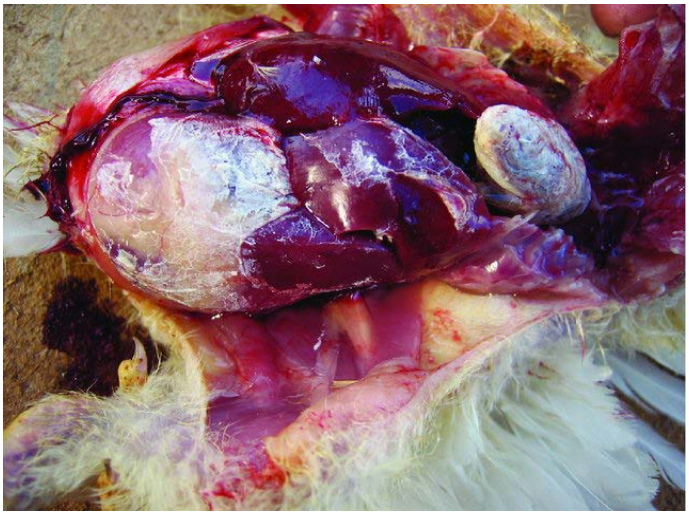


Figure 1: Photograph of affected chicken showing severe visceral gout (Gouthaman et al. 2015).

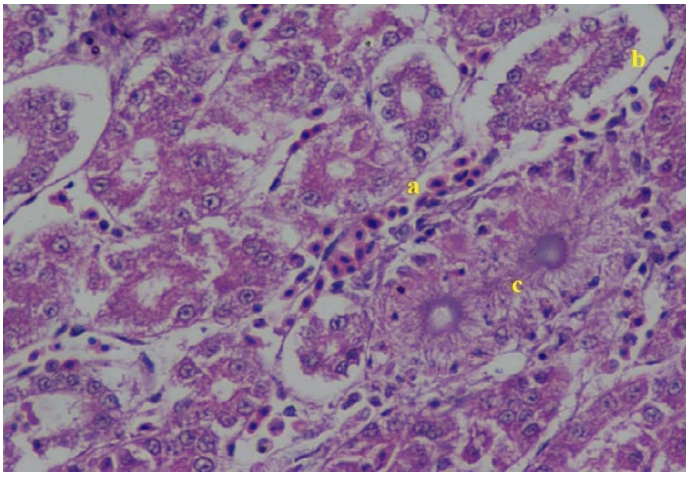


Figure 2: Photo micrograph of kidney showing intertubular haemorrhages (a), desquamation of tubular epithelium (b), urate crystal deposition in the tubules as radiating pattern (c) H&E X 400 (Sandhyarani et al., 2019a)

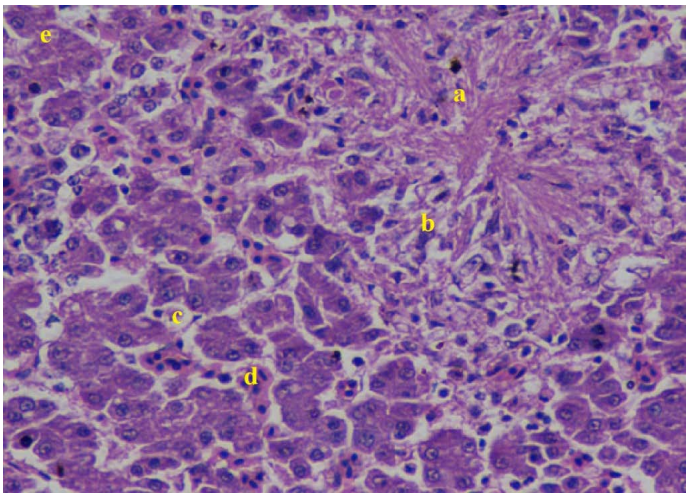


Figure 3: Photo micrograph of liver showing urate crystal deposition (a), leukocytic infiltration (b), sinusoidal dilatation (c), congestion (d), necrosed hepatocytes (e) H&E X 400 (Sandhyarani et al., 2019).

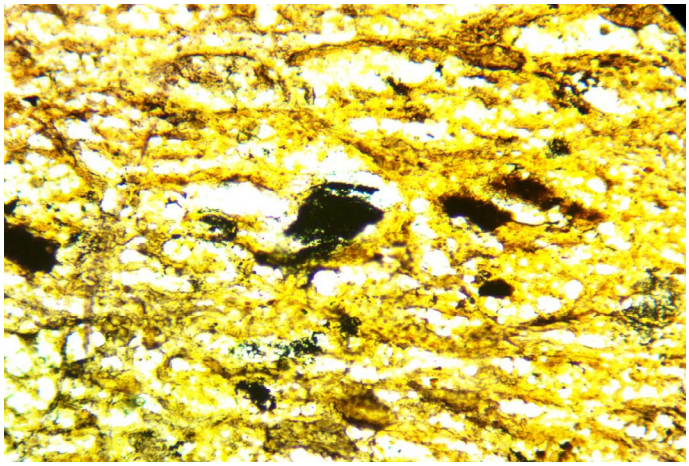


Figure 4: Photo micrograph of kidney showing black colored urate crystals Degalantha's stain X 400 (Sandhyarani et al. 2019a).

levels (>0.7-22mg/dl). This elevation in the level of serum uric acid might be due to failure of excretory function of kidney and to the increased degradation of nucleic acid released as a result of degenerative changes in various organs (Chandra et al., 1985). The observations like hyperuricaemia due to repeated use of NSAIDs at therapeutic level for prolonged period may induce marked renal dysfunction (Shafi et al., 2012). Similarly, Chandra et al. (1984) and Guo et al. (2005) had reported in their study that increased levels of uric acid in the birds provided with high calcium and high protein diets. Creatinine originates from the non enzymatic conversion of creatinine in muscle and filtered by glomerulus and excreted in the urine, so it can be used as a rough index of glomerular filtration (Benjamin, 1978). These parameters are markers of renal injury, possibly due to MSU crystal products in the kidney. The mean values of TEC, Hb, TLC and PCV in the affected birds were significantly (P>0.01) high (Jana et al., 2008; Singh et al., 2013; Yadav et al., 2020). The observation of increased levels of PCV, TEC, Hb values were possibly due to dehydration as a result of diarrhoea. The leucocytosis in the affected birds was mainly contributed by the absolute increase of lymphocytes was suggestive of the onset of cellular immunological response of the body of affected birds to any infection (Yadav et al., 2020) and may have stimulatory effect on bone marrow leading to leukocytosis (Thanagari et al., 2012; Singh et al., 2013; Shafi et al., 2015; Salam, 2017). The liver function markers AST and ALT were significantly increased in the birds effected with gout induced by high protein diet (Hong F et al., 2020) and diclofenac (Sandhyarani et al., 2019) which is an indication of hepatic injury. Antioxidant profile reveals decreased glutathione stimulating hormone (GSH) and increased thiobarbituric acid reactive substances (TBARS) in kidney and liver tissue (Singh et al., 2013; Akter and sarker, 2015; Sandhyarani et al., 2019). Glutathione (GSH) is an important intracellular peptide with multiple functions ranging from

antioxidant defense to modulation of cell proliferation (Lu, 1999). Glutathione plays a very important role in the detoxification and elimination of xenobiotics. Glutathione participates in many cellular reactions and effectively scavenges free radicals and other reactive oxygen species (ROS). Glutathione deficiency contributes to oxidative stress and therefore cause aging and the pathogenesis of many diseases. Most of the cellular GSH (85–90%) was present in the cytosol, with the remainder in all organelles (including the mitochondria, nuclear matrix, and peroxisomes (Wu et al., 2004). An exposure to xenobiotics induces mitochondrial injury involves generation of reactive oxygen species (ROS), causing oxidative stress to hepatocytes and results in depletion of GSH levels in poultry birds (Sokol et al., 2001). TBARS assay has been found to be one of the better predictor of oxidative damage (Morrow, 2000). Lipid peroxidation can be used as the hepatic oxidative stress parameters for measuring the damage that occurs in membranes of tissue due to result of free radical generation. The increase in superoxide dismutase levels and malondialdehyde (MDA) activity in renal tissue may indicate peroxidative damage and cause cell damage in kidney tissue (Gokcimen et al., 2001). Significant ($P \leq 0.05$) increase in serum aminotransferase, alkaline phosphatases, serum total proteins and serum albumin were also found in natural cases of gout positive birds (Feizi et al., 2011; Singh et al., 2013; Behtari and Feizi, 2015; Sandhyarani et al., 2019). Increase in total proteins in gout cases may be due the ammonia and carbonmonoxide if accumulated in sheds may affect the normal ventilation and ultimately reduced water intake lead to non availability of adequate water to flush out the urinary system leading to its clogging (Phatak, 2001). Lipid metabolic markers, such as total cholesterol (TC), triglycerides (TG),total bilirubin (TB), and direct bilirubin (DB) were decreased in the birds fed with high protein diet which induces an abnormal claw morphology in chicken, MSU crystal production in synovial fluid and other tissues induces renal injury in chickens and results in gout. (Hong et al., 2020).

Postmortem Lesions

Grossly, dry platery patches of white chalky urate deposits were observed on the serosal surfaces of pericardium, air sacs, peritoneum, liver, kidneys and ureters. Congestion of viscera might be due to emaciation and dehydration of birds leading to haemoconcentration (Satalkar, 2007). Nephropathy, observed consistently, was characterized by unilateral to bilateral enlargement which bulged out of the bony depression and moderate to severe congestion of kidneys. Kidneys appeared frosted due to accumulation of urate crystals, minute pin point haemorrhages along with chalky white deposits of urate crystals on the serosal surface. Ureters of either side were found to be distended with retained semi fluid to semisolid chalky white urates, giving cord-like appearance to ureters. The ureters were markedly enlarged due to blockages by uroliths and the entire obstructed kidney showed varying degree of degeneration (Lakkawar et al., 2018). Microscopically, marked congestion, hameorrhages involving glomeruli, cortical and medullary tubules, collecting ducts and medullary tracts and focal to diffuse degenerative changes in tubular epithelium like vacuolar degeneration, desquamated and necrosed tubular epithelial cells. Kidney parenchyma exhibited aggregates of uric acid crystals characterized by needle shaped urate crystals as pink radiating amorphous material surrounded by a narrow zone of inflammatory cells (Muhammed et al., 2012; Bulbule et al., 2013; Akter and sarker, 2015). Chandra and Balwant (1980) described the extent of damages to kidney was directly correlated to the degree of urate deposition. Hyaline casts were present in few tubular lumens. Glomerular changes included atrophy, distortion and segmentation (Mir et al., 2005).

Liver is enlarged, friable with white chalky urate deposition on the surface of the capsule. Liver section reveals severe sinusoidal congestion, haemorrhages in parenchyma, fatty change and foci of necrotic hepatocytes (Feizi et al., 2011; Sultana et al., 2012; Patel et al., 2014; Nitin and Ghosh, 2014; Amaravathi et al., 2015; Akter and sarker, 2015; Behtari and Feizi, 2015; Ramzan et al., 2015). Liver parenchyma shows amorphous radiating uric acid crystals mixed with necrotic debris surrounded by a narrow zone of inflammatory cells (Mudasir et al., 2017; Sandhyarani et al., 2019). Also the subcapsular hepatocytes were flattened with elongated nucleus and intense cytoplasmic basophilia along with proliferation of fibrous connective tissue in glisson's capsule (Mir et al., 2005).

In heart, the entire pericardium is covered with urate deposits of varying degrees on its serosal surface i.e uric acid pericarditis (Yewale, 2010). Pericardium is firmly adhered to heart. Myocardium of the heart showed urate deposition along with destruction of myocardial cells and infiltration of inflammatory cells. Lesions of heart included myocardial congestion because of severe engorgement of blood vessels and focal to diffuse haemorrhages between muscle fibers (Ramzan et al., 2012; Patel et al., 2014; Mudasir et al., 2017).

Lungs showed deposition of urates in the parenchyma, air capillaries and parabronchi. The air capillaries near tophi are collapsed and the remaining which are away from urate deposition showed emphysema. Oedematous fluid was present in air capillaries and atria (Mir et al., 2005).

Spleen showed splenitis and subcapsular haemorrhages. Urate deposits were observed in the subcapsular region as well as in the parenchyma (Mir et al., 2005).

Dry platery patches of white chalky urate deposits on the breast muscles, neck and on serosal surfaces of pericardium, peritoneum, mesentery, proventriculus, gizzard, testes,ovaries, over the abdomen and chest wall are also observed. Microscopically Proventriculus revealed oedema, haemorrhage and heterophilic infiltration in the serosa. Bursa of Fabricius presented mild depletion of lymphocytes in the follicles (Mir et al., 2005). These uric acid crystals were observed in black color by De Galantha's stain (Mohan et al., 2012; Patel et al., 2014; Patil et al., 2015; Sandhyarani et al., 2019). In the articular form white chalky nodules known as tophi found in tissues. It may occur in subcutaneous tissue other than joint which may cause ulcer but without severe pain (Ali and sultana, 2012). On opening the joints, white semifluid deposits of urates are present within the joints.

The deposits are also observed in almost all other joints including shoulder, elbow, carpus and phalanges in wings and hip, knee and toe joints in the limbs. Rarely some deposits were also observed in the cervical articulations. Arthritis with segmental necrosis of periarticular muscles and intermuscular oedema are also observed (Mir et al., 2005).

PREVENTION AND CONTROL

- A feed analysis is necessary, ensures the bird receives an appropriate intake of minerals, proteins and vitamins.
- For the prevention of gout in poultry, it is necessary to have scientifically balanced feed in respect of:

-Calcium-phosphorus ration depending on the type of ration.
-Vitamin A, D3 and other essential vitamins.
-Required level of sodium, chloride and other ions.
-Excessive use of sodium bicarbonate i.e. more than 2kg/ton should be avoided.
-Conventional sources of protein should be used.

- Analyse the feed for mycotoxin content and if found positive, change the feed or use suitable toxin binders.
- Judicious use of drugs such as antibiotics, sulpha drugs and anticoccidials to avoid kidney damage.
- Fresh potable water accessible to birds all the time.
- Copper sulphate should not be used for medication, if used should be used under the directions of a veterinarian or a poultry practitioner.

TREATMENT

- Provide plenty of water and adequate drinkers.
- Avoid a diet higher in protein than the recommended level as per the age and breed. Provide low protein diet for 3-5 days based on need depending on severity of gout.
- Review IB vaccination programme. In the areas where IB is endemic it is advisable to vaccinate with nephrotropic strain at around 4 days. Day one beak dip vaccination has proved to be beneficial in broilers.
- Use of urine acidifiers: Any one of the following urine acidifiers may be given in water or feed.
- Ensure adequate levels of A, D3, K and B complex vitamins.
- Vinegar: 1-2 ml per litre water up to 24 hours.
- Potassium chloride: 1gram per litre water up to 24 hours.
- Ammonium chloride: Two and half kg/ton feed for 7 days.
- Ammonium sulphate: Two and half kg/ton feed for 7 days.
- Use of electrolytes through water may assist in controlling mortality.
- Provide broken maize at least for 3 days and jaggery 5g/litre for 3-5 days in case of mortality.
- Allopurinol which available at 2.5-5% should be given 10-40mg in drinking water twice daily and never stop dosage until mortality percentage become zero.
- Provide 0.6% methionine hydroxyl analogue free acid with 3% calcium in the diet (Banday, 2009).

CONCLUSION

Gout is causing great monetary losses to the producers and considered as one of the major causes for huge mortality in poultry.

Most of the research work is done on gout and observe a strong link for bronchitis and calcium/phosphorus imbalance are the major causes of gout in chicken leads to high mortality. The other factors such as vitamins, chemicals, mycotoxins, water deprivation and electrolyte imbalanc are need to be recognized as possible contributing factors for gout. Likewise, in pullets and layers, the diet that increases urine alkalinity in combination with high calcium can contribute to gout. Chicken mortality due to gout can be reduced by increasing the acidity of the urine to dissolve existing kidney stones or to prevent additional kidney stones from forming. A regular feed analysis is necessary, ensures the bird receives an appropriate intake of minerals, proteins and vitamins. Breeder management along with hatchery and adequate farm management are crucial in preventing incidences of gout.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest.

NOVELTY STATEMENT

The current manuscript denotes how all nutritional, infectious and managemental factors contribute to cause gout in chicken individually. The gout causes, symptoms,

patho-physiology, clinical pathology, gross and microscopic lesions are furnished thoroughly in the manuscript. Hence one can analyse the results of the feed, blood and serum sample of suspected birds to reduce the morbidity and mortality of birds in the flock.

AUTHORS CONTRIBUTION

All authors contributed equally.

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