ANATOMY AND DISEASES OF THE PASSERINE AND RAMPHASTID DIGESTIVE TRACTS: IT GOES IN THE BEAK AND OUT THE VENT

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Although the basic design of the digestive tract is the same across many taxons, birds have developed variations in gastrointestinal anatomy and physiology that allows them to fill many of ecological niches and take advantage of a wide variety of foods. The following review will cover the anatomy, some function, and the diseases involving the digestive tract of commonly kept passerine and ramphastid birds. The review will start in the oral cavity and end with the cloaca.

ANATOMY OF THE ORAL CAVITY AND PHARYNX

In all birds, the oral and pharyngeal cavities form a common cavity called the oropharynx. The palate forms the roof of the mouth and a choanal fissure (choana) in the palate, connects the oral and nasal cavities. Birds do not have a soft palate. The palate has oral ridges that run lateral and rostral to the choana. These ridges are used for holding seeds when removing husks and are well developed in seed-eating passerine birds. The toma of the horny beak is the functional tooth structure.

Along the oral margins of the choana are small caudally projecting papillae. Similar papillae are on the roof of the oropharynx as well as around the infundibular cleft, on the tongue and the laryngeal mound. The infundibular cleft lies caudal to the choana on the roof of the oral cavity. The cleft connects the oral cavity with the middle ear and forms the common opening of the auditory tubes. Abundant lymphatic tissue is present within the walls of the cleft.

The shape of the tongue in passerine birds varies depending on their eating habits. Most passerine birds have a narrow, triangular tongue. There are no true intrinsic muscles in the tongues (muscles that lie entirely within the tongue structure) of passerine or ramphastid birds. At the base of the tongue is the laryngeal mound with the slit-like opening into the glottis. Birds do not have an epiglottis. The salivary glands are best developed in birds with a relatively dry type of diet (insect or seed eaters).

LESIONS OF THE ORAL CAVITY

Noninfectious Disease

With passerine birds, infectious disease agents are probably the most common cause of oral lesions. Ramphastid birds are more likely to present with traumatic lesions of the beak and may have associated lesions within the oral cavity. While vitamin A deficiency and subsequent oral lesions is a common disease in psittacine birds, it does not seem to be as much of a concern with passerine

birds and ramphastid birds.

Infectious Disease

Nearly every bird family or group has its own poxvirus that produces the typical skin and/or mucosa lesions. Sturnidae pox affects mynahs and starlings, causing scab like lesions around the beak, on eyelids, and over the head. Pox viral infections in finches and canaries may produce lesions on the feet and legs, in oral the cavity, and in the upper respiratory tract. Early in a flock outbreak the initial cases die of a fulminating pneumonia. The diphtheritic form carries a higher mortality rate of up to 50%. Later the typical cutaneous manifestations of proliferative papules, pustules, and nodules appear. These lesions may ulcerate and then crust over. The incubation period varies from 4 to 10 days and an outbreak can last four weeks or longer.

Transmission is mechanical by fomites or insects across injured or lacerated skin. The virus can remain viable for 16-19 days within mosquito salivary glands. A vaccine is available for some species.

Bacterial and fungal/yeast infections of the oral cavity are reported. These infections must be differentiated form poxvirus lesions and may be secondary to vitamin A deficiency. Acute infections may be haemorrhagic, but chronic infections with gram-negative bacteria or mycobacteria will lead to granuloma formation.

Trichomoniasis is more common in Australian finches and rare in canaries. Grossly, yellow-white nodules and plaques characterize oral and crop trichomoniasis. In severe cases there will be a sinusitis and associated respiratory clinical signs. Mockingbirds occasionally develop severe lesions of tissues of the face, throat and neck from tissue invasion of the protozoa. Grossly, the lesions are soft swellings that are red and highly vascular. In the live bird, the organisms are readily seen on a wet mount. They die rapidly after the bird's death.

Neoplastic disease

Tumors of the oral cavity are rarely reported in passerine and ramphastid birds. Malignant lymphoma is probably the most common tumor recognized.

ANATOMY OF THE OESOPHAGUS AND INGLUVIES (CROP)

The oesophagus is generally divided into the cervical oesophagus, ingluvies (crop), and the thoracic oesophagus. Both the cervical and thoracic oesophagus are lined by a relatively thick stratified squamous epithelium. The oesophageal wall is thin-walled but has a greater diameter than similarly sized mammals. There are subepithelial mucous glands. The cervical oesophagus generally runs on the right side of the neck.
The crop in most passerine birds is an enlarged spindle shaped area of the oesophagus. This is used as food storage and is lined by a stratified squamous epithelium. No mucous glands are present within the crop. Most ramphastid birds do not have a crop.

LESIONS OF THE OESOPHAGUS AND INGLUVIES (CROP)

Infectious Disease

Poxvirus infection can lead to proliferative and necrotic lesions similar to those described in the oral cavity.

Finch cytomegalovirus is a host specific alpha herpesvirus, related to laryngotracheitis virus of poultry. It appears to be a disease primarily of finches, especially Gouldian finches, and is characterized by high mortality, conjunctivitis, pharyngitis, oesophagitis, tracheitis, and bronchitis. The prominent gross lesion is a hyperaemic and oedematous conjunctiva. The viral inclusions are large intranuclear basophilic inclusion bodies within cytomegalic cells. The virus has a limited host range but outbreaks can last for weeks (reported up to seven weeks).

ANATOMY OF THE STOMACH (PROVENTRICULUS AND VENTRICULUS)

The stomach is composed of two sections, the proventriculus and the ventriculus. In passerine birds, it lies in the left dorsal and ventral coelom. The proventriculus is a thick spindle-shaped organ lined by a mucosa composed of compound tubular glands. These glands produce both pepsinogen and hydrochloric acid. There is an intermediate zone between the proventriculus and the ventriculus. This is a transitional area that opens into the ventriculus.

The ventriculus is responsible for mechanical digestion. It has a thick external muscularis, which supports the mucosa secreting the koilin lining layer. These ventricular glands secrete a carbohydrate-protein complex, which produces the dense thick serrated layer that will completely line the ventriculus. The koilin varies in strength in that the koilin formed within the crypts of the mucosa appear softer and wears faster than koilin from the gland tips, which results in a surface that is serrated. The koilin hardens in the middle to upper sections due to exposure from the hydrochloric acid from the proventriculus. The ventriculus, because of its muscular arrangement with the four semiautonomous smooth muscle masses that attach to extensive aponeuroses, acts as a food grinder with both rotary and crushing movements. In some fruit-eating species such as tanagers and toucans the ventriculus is poorly developed and thin walled.

LESIONS OF THE PROVENTRICULUS AND VENTRICULUS

Noninfectious Disease

Severe mineralization of the proventricular mucosa is seen in passerine birds and is believed to be secondary to excessive dietary calcium or ingesting excessive vitamin D_3. It can also be a secondary lesion to severe renal disease (mineralization of soft tissues). The lesion may not be noticeable grossly but the proventriculus may feel firm and slightly gritty.

Grit is small stones that are intentionally fed to birds for the purpose of mechanically assisting in digestion. Given the commercial diets available, most cage birds do not need grit. Occasionally a bird may consume too much and it will interfere with digestion and may result in starvation due to erosions and ulcerations of the ventriculus.

Infectious Disease

Infectious diseases affecting the proventriculus include viral, bacterial, mycobacterial, fungal, and parasitic.

Proventriculitis is frequently a component of systemic inflammatory disease processes. Most are due to bacterial infections although it is not uncommon to be unable to identify the disease agent. The more common systemic bacterial infections are due to *Escherichia coli*, *Enterobacter* spp, *Klebsiella* spp, *Salmonella* spp, *Yersinia pseudotuberculosis*, and *Campylobacter fetus var jejuni*. Mycobacteria have been reported in the proventriculus of passerine birds. Mycobacterial disease of the small intestine is far more common and it will be discussed in that section.

Canaries and finches are commonly identified with avian gastric yeast (megabacteriosis). *Macrorhabdus ornithogaster* (also known as megabacteria or avian gastric yeast) are large Gram-positive yeasts, PAS (periodic acid-Schiff) positive, and stain strongly with Calcofluor White MR2 (a chitin stain). In adult birds, weight loss and depression mark the infection ("going light"). The organism inhabits the lower portion of the proventriculus within the superficial mucosal glands at the isthmus. Disease may be dependent either on the pathogenicity of different strains or the individual susceptibility of the infected birds.

Endoventricular mycosis is seen in a variety of pet birds and is especially common in finches. Fungal organisms (usually *Candida* spp.) are found in the koilin layer and occasionally in the mucosa. The koilin is frequently fragmented. The clinical signs reported from the literature range from unexpected death to weight loss and passing intact seeds in the droppings. Various conditions such as recent shipping, crowded housing, reproductive activities, and mixed species aviaries are common recent stresses. Although antibiotic therapy is typically associated with secondary yeast infections, this is not a frequently reported occurrence with endoventricular mycosis.

Cryptosporidia of the proventricular glands and into the intestines is a common infection in finches. Cryptosporidia are intracellular protozoans that parasitize the apical portions of vertebrate oculorespiratory, gastrointestinal, and genitourinary epithelium. Although they are generally opportunistic and secondary invaders, they have been reported as primary pathogens producing respiratory and/or intestinal disease in birds. They appear responsible for debilitating diarrhea. There will be a variable mucosal hyperplasia of the proventriculus. Transmission is by ingestion of infective sporulated oocysts.

Gastric nematodes are also common. The number of metazoan parasites identified within the finch group is most likely a reflection on how many are maintained in breeding aviaries where they are frequently exposed to the parasite eggs or intermediate hosts. Spiruids, including, *Spiroptera* sp. and *Dyspharynx sp.* can colonize the proventriculus. They require an intermediate arthropod host and thus are primarily seen in birds kept outdoors. In severe chronic infections the wall of the proventriculus, particularly the mucosa, will be thickened, and the proventriculus may be distended. Perforation of the proventriculus can occur, but is uncommon.

Neoplastic Disease

Proventricular/ventricular carcinomas are described more frequently in canaries. Gastric carcinomas are often found at the proventricular-ventricular junction. If they extend to the serosal surface there may be peritonitis, fibrin deposition and adhesion to the liver or other organs.

ANATOMY OF THE INTESTINES

The intestines are relatively simple and are the site of chemical digestion and food absorption. The first loop of the intestine is the duodenal loop, which is the most ventral part of the intestinal mass. This encircles the pancreas and receives the pancreatic and bile ducts. Although the jejunum and ileum are not well delineated, the remnant of the yolk sac, the vitelline diverticulum, marks the junction.

Passerine birds have vestigial caeca. Submucosal lymphoid tissue is found normally in many species of birds particularly in the distal ileum and in the tips of the caeca. This tissue can significantly alter the shape of the villi.

The colorectum is a short section of intestine from the ileocaecal junction to the cloaca. The villi are shorter than those in the small intestine.

LESIONS OF THE INTESTINES

Noninfectious Disease

Amyloidosis and mineralization may occur in the intestinal tract, usually with no gross change noted. Mineral is found most frequently in vascular walls and amyloid in vessel walls and the mucosal lamina propria.

Infectious Disease

Paramyxovirus-1 [Exotic Newcastle Disease] can potentially infect many species of pet birds. Lesions are variable but gross haemorrhage and necrosis may be present in the intestines of some birds. Histologically the lesions are due to a vasculitis of the intestinal wall, and necrosis of submucosal lymphoid tissue.

A variety of bacteria cause enteritis in psittacine birds. Gram negative pathogens can be primary or secondary invaders. Mycobacterial infections occur sporadically in many species of pet birds. The primary site of infection for the *M. avium/intracellulare* complex and *M. genavense*, the two most common causes of mycobacteriosis in birds, is the intestinal tract. Gross lesions include diffuse and/or nodular thickening and opacification of the intestinal wall. Generally by the time of diagnosis, the infection is systemic.

The most common intestinal parasites are *Cochlosoma* spp., *Eimeria* spp., *Cryptosporidium* spp., *Atoxoplasma* spp, *Trichomonas* spp., *Giardia* spp., and several genera from the family *Anoplocephalidae*. *Eimeria* spp. and *Atoxoplasma* spp. infections are more common in canaries. Cestodes, cryptosporidia, trichomonads, *Giardia* spp., and *Cochlosoma* spp. occur more frequently in other finches. Ramphastid birds most commonly have *Giardia* spp., ascarids, coccidia, and capillarias.

Giardia spp. and *Spironucleus* spp. (previously classified as *Hexamita*), are two flagellates associated with intestinal disease. These organisms may result in minimal gross change. Excessive fluid and mucus as well as mucosal hyperaemia is seen in some birds. Flagellates disappear from the intestine rapidly if the intestines are not immediately preserved. Wet mounts of intestinal scrapings, particularly duodenal, from a bird that has just died are the most sensitive means of finding these

organisms. Each of these organisms has characteristic shapes and movements, making the wet mount an excellent means of differentiating them.

Several apicomplexa coccidial parasites can be found within the intestinal mucosal epithelium. In the canary these coccidia may represent either *Isospora canaria* or *Atoxoplasma serini*. *I. canari* is strictly an intestinal coccidium and severe infestations have been associated with very young or immune compromised birds. Diagnosis of these parasites is made by examination of a faecal flotation or direct faecal smears; however, oocyst shedding is intermittent so a negative faecal examination is not diagnostic. Atoxoplasmosis is a common parasitic disease diagnosed in the subadult canary. This host-specific protozoan undergoes a sexual phase in mononuclear blood cells. It is transmitted to other birds through ingestion of faecal oocysts. Treatment for either of these parasites with sulfa drugs will only reduce the number of infective oocysts, and has no effect on intracellular stages.

Metazoan parasites are infrequent causes of clinical disease in well-managed aviaries or in household pets. Cestodes are occasionally diagnosed at necropsy and are particularly common in Australian finches. There is usually no associated gross or histologic lesion.

Neoplastic Disease

Lymphosarcoma (malignant lymphoma) is a common neoplasm of passerine birds. To date, there has been no evidence of a viral link to the tumour formation in these birds. Of the finches, canaries are over-represented for this tumor type. This neoplasm develops in primary and secondary lymphoid tissues and spreads to other tissues. Lymphosarcoma of the intestinal tract usually presents as a diffuse or nodular thickening that must be differentiated from conditions such as mycobacteriosis. The clinical signs associated with the neoplasm can be non-specific and include depression, anorexia, weight loss, paresis, lameness, abdominal swelling, diarrhoea, blindness, regurgitation, feather loss, and self-mutilation. Many birds will have a marked peripheral lymphocytosis and frequent secondary infections.

ANATOMY OF THE CLOACA

The cloaca is the combined outflow tract of the digestive, urinary, and reproductive tracts. The colorectum enters into the coprodeum, the ventral aspect of the cloaca. Dorsally is the urodeum into which the ureters empty; it is separated by a horizontal fold of tissue from the coprodeum. The oviduct in the female enters the urodeum from the left lateral wall. The deferent ducts (vas deferens) enter the urodeum in the male. The urodeum and coprodeum open into the common chamber of the proctodeum. The males of many passerine birds have a cloacal promontory. This conical projection is the end of the vas deferens as it enters the cloaca.

LESIONS OF THE CLOACA

Noninfectious Disease

There are a variety of causes of cloacal prolapse. The prolapsed mucosa will appear nodular or proliferative and there may be areas of necrosis and haemorrhage.

Infectious Disease

Infections affecting the cloaca are the same as those seen in the intestinal tract.

ANATOMY OF THE PANCREAS

The largest portion of the pancreas lies within the loop of the duodenum. This portion extends cranially and may come in contact with the spleen. The normal pancreas is yellow to yellowish pink with a finely lobulated surface. Histologically it contains both exocrine and endocrine tissues that resemble its mammalian counterparts. Islets are not uniformly distributed in the pancreas and multiple sections from different portions of the pancreas must be collected if the islets are to be seen and evaluated.

LESIONS OF THE EXOCRINE PANCREAS

Infectious Disease

Viral and bacterial agents reported to cause pancreatitis, include herpesvirus, polyomavirus, adenovirus, paramyxovirus [PMV-3], poxvirus, a variety of Gram negative bacteria, and *Chlamydophila* spp. Gross lesions vary from none to haemorrhage and necrosis and there may be a heterophilic exudate in cases of bacterial pancreatitis.

Paramyxovirus can cause chronic pancreatitis, particularly in small passerine birds. The pancreas will be firm and irregular. A variable lymphoplasmacytic and histiocytic inflammatory response and lymphoid follicle formation characterize the lesion, occasionally with fibrosis.

AVIAN DIGESTIVE PHYSIOLOGY

Starting in the mouth, touch receptors are found in rich supply on the tongue, oral cavity, and beak. Avian taste buds are generally located in the oral cavity on the floor of the pharynx and at the base of the tongue. Nectarivores are able to differentiate between sugar solutions based on composition and concentration. Tannins can be detected in certain plant foodstuffs in birds that are folivores (plant-based diets).

Movement of food through the gastrointestinal tract of birds is similar to that of mammals, going in the general direction from the mouth to the vent. However, in many birds, it has been recognized that retrograde movement of digesta will occur between the proventriculus and the ventriculus, the small intestine and the ventriculus, the colorectum and the small intestine, and the cloaca and the colorectum. The reflux of the digesta between the proventriculus and ventriculus optimizes the action of enzymatic and mechanical digestion. The reflux from the cloaca to the colorectum helps to resorb protein, salt, and water present within the urine.

Food leaves the oral cavity and enters the oesophagus, which widens to the crop. The crop allows for storage as well as softening of food for more efficient digestion. The softening is due to hydration by saliva added to the food during swallowing and any mucus that may be secreted into the crop. As food passes through the proventriculus, it is coated with acid and pepsin. It rapidly moves to the ventriculus, and contractions of the ventriculus will crush the food into smaller particles. Larger food particles may reflux back into the proventriculus for addition of fresh pepsin and hydrochloric acid. Food moving into the small intestine undergoes enzymatic digestion. Protein starches and nucleic acids are hydrolyzed within the lumen of the small intestine by the pancreatic enzymes. Intestinal lactase has not been identified in those birds tested. This suggests that most birds are unable to

digest lactose-containing foods. Some frugivorous and nectarivorous species have exceptionally long intestinal microvilli, which is presumed to aid the absorption of the free sugars that are found in their food.

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