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A brief review of pigeon circovirus infection worldwide

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Abstract Pigeon circovirus infection is an immunosuppressive disease of pigeons carried on by the widely recognized virus known as Pigeon circovirus (PiCV). Additionally, due to PiCV's immunosuppressive activity, a group of diseases collectively known as the "young pigeon disease syndrome" (YPDS) occurs. This study aims to provide information about pigeon circovirus infection transportation throughout the world, the symptoms that have been identified as the disease has progressed, and the diagnostic methods that have been recently developed for the detection of pigeon circovirus. Pigeons of all ages may develop the disease affecting meat and racing pigeons. PiCV-infected pigeons exhibit symptoms such as ruffled feathers, depression, anorexia, weight loss, regurgitation, poor racing performance, diarrhea, and polydipsia. However, asymptomatic PiCV infection has been reported. Most typical and characteristic pathological lesions were the presence of massive basophilic intracytoplasmic inclusion bodies in the thymus, spleen, bursa of Fabricius, and other lymphoid tissues, which are diagnostic. Real-time quantitative and digital droplet PCR techniques have been developed lately for viral detection and quantification.

Keywords: immunosuppression, PiCV, PCR techniques

1. Introduction

Pigeon circovirus infection is an immunosuppressive disease of pigeons caused by a virus called Pigeon circovirus (PiCV), which is identified globally. PiCV, additionally, is responsible for a complex of diseases collectively known as young pigeon disease syndrome (YPDS) due to its immunosuppressive action (Stenzel and Pestka, 2014). Despite the significant viral loads seen in various tissue samples, notably in the bursa of Fabricius, PiCV is regularly inspected, analyzed, and reported in pigeons less than one-year-old. Most of these birds displayed no symptoms (Todd et al 2002). PiCV infection occurs in meat and racing pigeons and may arise in all ages (A.Stenzel et al 2014). PiCV infection was first recognized in the late 1980s in Canada and Australia (Woods et al 1994). Also, It has been detected in Europe, Asia, and South Africa (A.Stenzel et al 2014). The PiCV was observed to transmit both vertically and horizontally. The virus was found in the colon, cloaca, and feces, indicating fecal-oral transmission (Duchatel et al 2006). This study aims to present information on the global transportation of pigeon circovirus infections, the symptoms that have been recognized as the disease has developed, and the diagnostic techniques that have recently been established for the detection of pigeon circovirus.

2. Cousetave agent

The disease was caused by Pigeon circovirus (PiCV), which belongs to the family of *Circoviridae*, species *Pigeon circovirus* of the genus of *Circovirus*. In 2005, the viral species was officially accepted as a new species of the genus *Circovirus*. Circoviridae belongs to the order *Cirlivirales*, class *Asfiviricetes*, phylum *Cressdnaviricota*, kingdom *Shotokuvirae*, and realm *Monodnaviria* as it is revealed in the viral taxonomic report 2019 (Silva et al 2022). Pigeon circovirus (PiCV) is a non-enveloped, small virus with a circular and single-stranded DNA genome of the average size of 2.0 kb; there is a slight variation in PiCV among length with other strains (Cságola et al 2012). Todd et al (2008) showed that the PiCV genome comprises two genes transcribed bidirectionally from a double-stranded replicative intermediate. The virion sense gene rep encoded the replication protein (Rep) of the virus, while the capsid protein (Cap) was by the complementary sense gene *cap* (Todd et al 2001). PiCV, like other circoviruses, is genetically varied and tends to be genetic.

3. PiCV transmission

Both vertical and horizontal transmission of PiCV were noticed. Fecal-oral virus transmission was revealed by its detection in the intestine, cloaca, and feces. (Duchatel et al 2006). Also, a respiratory route of viral transmission has been suggested when the bird inhales the contaminated feather dust. The previous reports of the virus detection in the pharynx, trachea, and lungs raise the possibility that respiratory tissues might be a strategic location for the virus's replication and

persistence, particularly among older pigeons. (Duchatel et al 2006). Vertical transmission, on the other hand, was demonstrated by the identification of the virus in the testis and sperm of breeding cocks, the ovary but not the oviduct of hens, embryonated eggs, and chicks retrieved from eggs just before hatching. (Duchatel et al 2009). It was discovered that the virus was more frequently found in pigeon embryos than previously believed. According to reports, 11 and 36% of embryos may have had the virus before hatching. (Duchatel et al 2005) . The virus has been detected by its DNA in the Fabricius' throat, trachea, lung, liver, spleen, gut, kidney, heart, and bursa, suggesting the virus infection targets no particular embryonic tissue. (Duchatel et al 2006). Weaning and the subsequent transfer to the rearing loft coincide with detecting the virus in 100% of the birds, suggesting a high likelihood of virus transmission and new infection in rearing lofts, according to the observation of the status of viral infection during the first few weeks after hatching. While detecting the virus DNA in cloacal swabs of pre-weaning (up to 28 days old), chicks only ranged from 1-20% (Duchatel et al 2006). Furthermore, it's interesting to note that although viral DNA was found in crop tissues of young birds by in situ hybridization, viral DNA detection by PCR of crop swab samples produced a negative result, indicating that the virus's excretion and transmission through crop milk are uncommon. (Duchatel et al 2005).

4. PiCV infection

PiCV is frequently investigated and reported in pigeons under one year old, most of which showed no symptoms despite the high virus loads seen in several tissue samples, especially in the bursa of Fabricius (Todd et al 2002). In particular, the virus has also been found in tissue samples from the spleen, liver, thymus, kidney, crop, intestine, brain, trachea, lung, heart, blood, bone marrow, esophagus, Peyer's patch, nose, and third eyelid in differing percentages in various publications using different methodologies. (Todd et al 2002 ; Duchatel et al 2005). Compared with the young pigeon, detecting the virus in the old pigeon (more than a year old) in respiratory and spleen tissue samples was more common than the viral investigation in pharyngeal, blood, and cloaca (Duchatel et al 2006; Duchatel et al 2005).

5. Clinical and pathological manifestation of PiCV infection

Around four-month-old pigeons are believed to be most susceptible to PiCV infection. (Tavernier et al 2000). Pigeons with PiCV infection show symptoms such as ruffled feathers, depression, anorexia, weight loss, regurgitation, poor racing performance, diarrhea, and polydipsia. Nevertheless, asymptomatic PiCV infection is documented (Stenzel and Pestka, 2014). Histopathologically, the presence of large basophilic intracytoplasmic inclusion bodies in cells at the site of infection is a typical and characteristic pathological feature of the PiCV infection (Scullion and Scullion, 2007). Most frequently, the inclusion bodies are present in the thymus spleen, bursa of Fabricius, and other lymphoid tissues. (Schmidt et al 2008). The primary target organ of the PiCV is the bursa of Fabricius; then, secondarily, the other lymphoid organs become infected, resulting in immunosuppression. The lymphoreticular system is more commonly affected than other organs in circovirus-infected pigeons (Shivaprasad et al 1994). (Huang et al 2017) For the first time, the inclusion bodies were present in the esophagus, gizzard, thyroid gland, and third eyelid and were revealed by transmission electron microscopy. Also, lymphohistiocytic infiltration was observed (Figure 1 (a,b,c, and d respectively)) (Huang et al 2017).

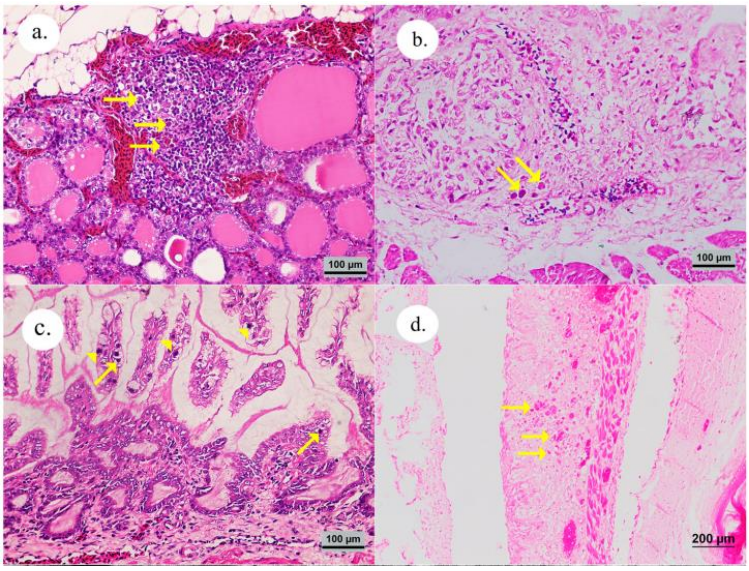

Figure 1 Pigeon circovirus infections with (a) Infiltration of lymphohistiocy in the thyroid gland with intracytoplasmic inclusion bodies (arrows) (H&E stain). (b) Esophagal lamina propria and submucosa with intracytoplasmic inclusion bodies (arrows) (H&E stain). (c) Gizzard mucosa with intracytoplasmic (arrows) and intranuclear (arrowheads) inclusion bodies (H&E stain). (d) A low-power microscope view of the third eyelid with intracytoplasmic inclusion bodies (arrows) (H&E stain) (Huang et al 2017).

6. The Immunosuppressive Role of PiCV

The typical lesions of PiCV infection in the bursa of Fabricius and the spleen with the detection of PiCV DNA in the cloaca support the purported immunosuppressive action of PiCV in pigeons (Schmidt et al 2008). This immunosuppressive activity of PiCV was more recently supported by analysis of the lymphocyte groups in both symptomatic and asymptomatic PiCV-positive and PiCV-negative pigeons. PiCV infection was discovered to trigger B lymphocyte apoptosis, which impairs humoral immunity (Stenzel et al 2020). These two pieces of research may be the greatest proof to dispel doubts about PiCV's immunosuppressive effects.

7. Diagnosis

Before the pigeon circovirus genome discovery, identification and diagnosis of infection relied mainly on histological analyses and electron microscopy discoveries of intracytoplasmic and/or intranuclear inclusion bodies in lymphoreticular and hepato-intestinal organs. (Silva et al 2022).

Using a polymerase chain reaction, PiCV has regularly been detected in tissues, intestinal contents, and formalin-fixed, paraffin-embedded tissues (PCR) (Roy et al 2003). PiCV has also been identified in pigeon feathers, feces, crop secretions, blood, and macrophages. (Bougiouklis, 2007). Franciosini et al (2005) developed a PCR-based diagnosing method to identify the asymptomatic PiCV infection and discovered that the primary transmission mode was most likely horizontal.

The PiCV genome's first complete sequencing was presented by Mankertz et al (2000s), paving the way for a more exact infection detection method. Although high-throughput sequencing is the most complex method ever used to identify PiCV, it is inappropriate for diagnostics due to its complexity, expense, and time for result production (Kong et al 2021). Nucleic acid-based diagnostic methods were developed and evaluated, such as PiCV-specific PCR techniques, in situ hybridization, and dot blot analysis (Duchatel, 2009; Silva et al 2022). Real-time quantitative and digital droplet PCR techniques have been developed lately for viral detection and quantification to relate viral load to the host's clinical condition (Stenzel et al 2020).

8. Control

Currently, no commercially available vaccination prevents PiCV infections (Silva et al 2022). The literature has reported on experimental research on developing the recombinant capsid protein and assessing its potential use as an antigen for vaccine formulations. (Khalifeh et al 2021). Probiotics and interferons have also been studied as additional or alternative methods for controlling the consequences of PiCV infections (Tsai et al 2021). Effective biosecurity precautions in the loft are required to prevent against potential negative impacts of PiCV infection. Although hygiene rules are readily implemented in meat pigeon farms, the same cannot be said for racing pigeon lofts (Stenzel and Koncicki 2017).

9. Final Considerations

Pigeon circovirus infection occurs worldwide and is characterized by immunosuppressive in pigeons caused by Pigeon circovirus, which belongs to the family of *Circoviridae*, a species of *Pigeon circovirus* of the genus of *Circovirus*. Due to PiCV's immunosuppressive activity, young pigeon disease syndrome (YPDS) is occurring. Real-time quantitative and digital droplet PCR techniques have been used lately for viral detection and quantification.

Ethical considerations

Not applicable.

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Conflicts of interest

The authors declare no conflicts of interest.

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