

Tiny Virus, Big Impact: What You Need to Know About PCV2

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Abstract

Porcine Circovirus Type 2 (PCV2) is a globally significant pathogen responsible for a range of disease syndromes collectively termed Porcine Circovirus Associated Diseases (PCVAD), including the economically devastating Post-Weaning Multisystemic Wasting Syndrome (PMWS). This article provides a comprehensive overview of PCV2, detailing its virology, transmission dynamics, clinical manifestations, and the multifactorial nature of PCVAD development. Emphasis is placed on the role of co-infections, environmental stressors, and genetic susceptibility in disease progression. The shift in dominant PCV2 genotypes over time, particularly the rise of PCV2d, and its implications for vaccine efficacy are also discussed. Diagnostic approaches, including molecular and immunohistochemical methods, are reviewed alongside current prevention and control strategies such as vaccination, biosecurity, and farm management practices. This article aims to equip veterinarians, researchers, and swine producers with essential information for mitigating PCV2 impact on pig health and productivity.

Introduction

A variety of viral diseases affect susceptible pigs being bred for pork production. These include infections from African swine fever virus (ASFV), Classical swine fever virus (CSFV), swine influenza A virus (IAV), porcine parvovirus (PPV), Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) and porcine circovirus (PCV). Sometimes these infectious agents also co-infect susceptible pigs causing an even severe disease. This article covers a brief overview of porcine circovirus 2 which is the causative agent of porcine circovirus associated diseases (PCVADs).

Circoviruses are small (17-22 nm diameter), circular, single stranded DNA viruses with a 1.7 Kb genome, belonging to the Circoviridae family. Currently, porcine circoviruses have four reported

types PCV1, PCV2, PCV3 and PCV4. PCV-1, discovered as a contaminant of PK-15 cells in 1974 is non-pathogenic in pigs (Tischer et al., 1974; Tischer et al., 1986; Allan et al., 1995). Discovered in 1988, PCV2 is the etiological agent involved in postweaning multisystemic wasting syndrome (PMWS). More recently, the term porcine circovirus associated diseases (PCVAD) is used to describe all the disease syndromes associated with PCV2 (Segalés, 2012). PCV3, responsible for causing porcine dermatitis and nephropathy syndrome (PDNS) in pigs was discovered in 2016 (Tan et al., 2021) and PCV4 was subsequently discovered in 2019 (Zhang et al., 2020).

Disease Caused by PCV2

PCV2 has been shown to be involved in Post-Weaning Multisystemic Wasting Syndrome PMWS. Post-Weaning Multisystemic Wasting Syndrome (PMWS) is characterized by weight loss,

breathing discomfort, jaundice, and peculiar microscopic lesions in lymphoid tissues of infected pigs (Clark, 1997; Harding, 1997). Other than PMWS, PCV-2 has been associated with numerous other disease conditions also such as Porcine Respiratory Disease Complex (PRDC), Porcine Dermatitis and Nephropathy syndrome (PDNS), enteritis, reproductive failure, Proliferative and Necrotizing Pneumonia and more (Opriessnig et al., 2007). All these clinical conditions are collectively termed as porcine circovirus associated diseases (PCVAD) (Segalés, 2012).

Transmission

PCV2 is present in high concentrations in the nasal and fecal excretions as well as the serum for extended periods of time. Following natural PCV2 infection, early and persistent shedding from these routes provides access for the virus to be transmitted from infected to susceptible animals. Some less common yet significant routes for transmission of PCV2 are through semen and consumption of infected milk (Rose et al., 2012).

Horizontal transfer of the virus may occur by direct nose-to-nose contact or via the fecal-oral route especially if PCV2 infected pigs commingle with naïve pigs. Other sources of potential introduction and persistence of PCV2 are fomites and other animal species such as rodents. Another major source of PCV2 contamination is farm workers i.e., their work-wear and boots. This is of importance because the movement of workers throughout the different farm facilities including the office and the farm perimeter helps transmit the virus to all the farm dependencies (Diaz Cao et al., 2018; López-Lorenzo et al., 2019).

PCV2 infection in pigs results in lymphoid depletion and immunosuppression as the virus strongly impacts T-cell selection process in the lymphoid tissue. This leads to increased susceptibility to other viral and bacterial infections, leading to the onset of coinfections. Bacterial infection, vaccination failure, stress or crowding along with PCV2 can also lead to PCVD/PCVAD.

General epidemiology of PCV2

Currently PCV2d predominates worldwide (Guo et al., 2010; Xiao et al., 2015). PCV2 genotype 2a was the most prevalent until 2003, when a genotype shift, originating in Europe, occurred in favor of genotype 2b (Segalés et al., 2013), with a parallel enhancement of the outbreak severity (Corman et al., 2008; Constans et al., 2015). Now

PCV2d is rapidly replacing PCV2b prevalence. PCVs have the highest evolutionary rate (about 10^{-3} - 10^{-4} substitutions/site/year) amongst DNA viruses. This high evolutionary rate along with the huge population size provides optimal conditions for natural selection to act. One of the reasons for its wide acquired genetic variability could also be due to vaccination-induced immunity escape (Firth et al., 2009; Shen et al., 2012).

A wide variety of factors contribute to the risk of developing PCVD which include on-farm management, husbandry conditions, genetic influence of breed susceptibility to PCVD and co-infections with other pathogens (Rose et al., 2012).

The on-farm management and husbandry conditions include the housing of pigs, proximity to other pig farms, vaccination schedules, hygiene and husbandry practices and biosecurity i.e. whether visitors avoid contact with the pigs for several days before visiting the farm (Rose et al., 2012). The genetic influence of breed susceptibility to PCVD has also been studied extensively based on field evidence. In experimental studies, it has been observed that Landrace pigs are more susceptible to PCVD than Duroc, Large white and Pietrain pigs (Opriessnig et al., 2006; Opriessnig et al., 2009; Lopez-Soria et al., 2011). Coinfections with pathogens such as PPV, PRRSV, PCV3, swine influenza virus and *Mycoplasma hyopneumoniae* or with different PCV2 strains also contribute greatly to the risk of severe PCVD/ PCVAD (Yi and Liu, 2010; Opriessnig and Halbur, 2012; Meng, 2013; Ren et al., 2016; Wang et al., 2016; Ouyang et al., 2019).

Diagnosis

Due to the ever-increasing spread of the virus, accurate diagnostic methods are vital for proper prevention and control of PCVAD (Opriessnig et al., 2007). The diagnosis can either be done tentatively on the basis of clinical manifestations (i.e. loss of weight, diarrhea, lymphadenopathy, jaundice, reproductive failure etc) or on the basis of confirmatory detection of the PCV2 antigen in the tissues and organs of the affected animal. The gold-standard diagnostic tests for PCV2 antigen detection are polymerase chain reaction (PCR), immunohistochemistry (IHC) and in situ hybridization (ISH) (Opriessnig et al., 2007; Afolabi et al., 2017). Other tests also being used include enzyme linked immunosorbent assay (ELISA), immunofluorescence assay (IFA), IgM

immune-peroxidase monolayer assay, serum virus neutralizing assays, virus isolation and electron microscopy (Larochelle et al., 2000; Sibila et al., 2004; Opriessnig et al., 2007; Cruz et al., 2016).

Prevention and Control

Vaccination is the most effective strategy to control a multifactorial disease such as PCVAD, along with other preventive strategies such as improvement of swine management, control of co-infections etc. The currently available commercial PCV2 vaccines are given in Table 1. Since all the currently available vaccines are based on the PCV2a genotype, concerns have been raised by scientists that these may not be effective against the currently spreading PCV2d genotype, which is more closely related to PCV2b (Xiao et al., 2015; Opriessnig et al., 2019). PCV2 mass vaccinations can reduce PCV2 infection pressure but not completely eradicate the pathogen from swine herds. Vaccine strategies can alter the equilibrium between host and pathogen, and modify the competitive hierarchy among viral strains and might be conditioning the evolution and epidemiology of PCV2 (Franzo et al., 2016).

Table 1: Commercially available PCV-2 vaccines and their features

Vaccine	Manufacturer	Antigen	Usage
CIRCOVAC®	Merial	Inactivated PCV2a virus	Breeding sows (>3 weeks old)
Ingelvac CircoFLEX®	Boehringer Ingelheim	PCV2a capsid protein	Piglets > 3 weeks old
Circumvent®	Merck	PCV2a capsid protein	Piglets > 3 weeks old
Porcilis® PCV		PCV2a capsid protein	Piglets > 3 weeks old
Foster™ PCV (formerly Suvaxyn® PCV2 One Dose™)	Pfizer Animal Health	Inactivated attenuated chimeric PCV1-2a virus	Piglets > 3 weeks old

Other than vaccination a combination of good management practices has played a very important role in the prevention and control of PCVAD. These practices are basically focused on minimizing stress, eliminating co-infections or minimizing their effects, and eliminating potential triggering factors that might induce immune stimulation and trigger progression of PCV2 infection to PCVAD. Four golden rules have been suggested 1) limiting pig to pig contact 2) stress reduction 3) good hygiene and 4) good nutrition.

Regular cleaning and disinfection including all the utensils, materials and machines stored in farm premises is of utmost importance. These cleaning and disinfection protocols must include any and all the facilities that the farm workers access regularly. Adoption of measures such as pressure washing of visiting vehicles, and posterior disinfection (disinfection gates, wheel baths etc) is advisable to prevent the spread of PCV2 to other farms (López-Lorenzo et al., 2019). PCV2 is highly resistant in the environment, thus, the use of oxidizing, halogen or sodium hydroxide containing products is recommended because of their effectiveness (Rose et al., 2012).

Conclusion

PCV2 remains a formidable challenge in modern swine production due to its ability to cause immunosuppression, its association with multiple disease syndromes, and its high evolutionary rate that allows for genotype shifts and potential vaccine escape. While vaccination and improved farm management have significantly reduced the clinical burden of PCVAD, complete eradication of the virus remains elusive. Continuous monitoring, stringent biosecurity measures, and updated vaccination strategies tailored to the prevailing genotypes are essential to control its spread effectively. Moreover, minimizing co-infections and stressors, along with educating farm personnel about hygiene and biosecurity, are crucial components in reducing disease incidence. As our understanding of PCV2 evolves, so must our approaches—ensuring sustainable pig health and farm profitability through science-driven, integrated disease management strategies.

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