

Swine Influenza: Pathobiology, Pulmonary Lesions, Diagnosis and Its Significance in Porcine Respiratory Disease

Sourabh Babu¹, Vivek Kumar¹, Chandrakanta Jana², Rajveer Singh Pawaiya³, Sanjay Kumar Yadav⁴ and Mahesh Kumar⁴

¹Ph.D. Scholar, Division of Pathology, ICAR–Indian Veterinary Research Institute (ICAR-IVRI), Izatnagar, Bareilly, Uttar Pradesh, India, ²Principal Scientist, Division of Pathology, ICAR–Indian Veterinary Research Institute (ICAR-IVRI), Izatnagar, Bareilly–243122, Uttar Pradesh, India, ³Principal Scientist & Head, Division of Pathology, ICAR–Indian Veterinary Research Institute (ICAR-IVRI), Izatnagar, Bareilly–243122, Uttar Pradesh, India, ⁴Ph.D. Scholar, Division of Surgery and Radiology, ICAR–Indian Veterinary Research Institute (ICAR-IVRI), Izatnagar, Bareilly, Uttar Pradesh, India.

ARTICLE HISTORY

Received: August 01, 2026
Accepted: August 01, 2026
Published: August 30, 2026

Abstract

Swine influenza is an acute, highly contagious respiratory disease of pigs caused predominantly by influenza A viruses. The disease is important from a veterinary pathology perspective because viral replication in the respiratory epithelium produces epithelial injury, inflammation and characteristic pulmonary lesions, while disruption of mucociliary defence may facilitate secondary bacterial infection. Clinically, affected pigs may show sudden fever, depression, anorexia, coughing, sneezing, nasal discharge and respiratory distress. At necropsy, the lungs commonly show multifocal to coalescing, dark-red to purple, firm and depressed areas of consolidation, particularly in the cranial and middle lobes. Microscopically, acute bronchointerstitial pneumonia, bronchiolar epithelial degeneration and necrosis, loss of ciliated epithelium, inflammatory exudation and alveolar changes may be observed. Because similar lesions occur with other respiratory pathogens, diagnosis should integrate clinical history, gross pathology, and histopathology and laboratory confirmation, particularly real-time reverse transcription polymerase chain reaction (rRT-PCR). Control depends on biosecurity, appropriate herd management, adequate ventilation, vaccination where indicated, surveillance and timely recognition of secondary infections. The One Health importance of swine influenza also reflects the genetic diversity and reassortment potential of influenza A viruses. This article highlights the disease from a pathology-oriented perspective, emphasizing how lesion development helps explain clinical disease, complications and diagnostic decision-making.

Corresponding authors email: babusourabh82@gmail.com

DOI: <https://doi.org/10.5281/zenodo.22774222>

Keywords: swine influenza; influenza A virus; pulmonary lesions; bronchointerstitial pneumonia; histopathology; rRT-PCR; secondary infection; veterinary pathology

Introduction

Swine influenza is an important and highly contagious respiratory disease of pigs caused predominantly by influenza A viruses. It is characterized by sudden fever, depression, anorexia, coughing, sneezing, nasal discharge and varying degrees of respiratory distress. Although uncomplicated infection generally has a low mortality rate, its impact on swine production can be considerable because of reduced feed intake, impaired growth, treatment costs, secondary bacterial infections and prolonged recovery. Influenza A virus is recognized as a primary pathogen within the porcine respiratory disease

complex, where concurrent infections can increase disease severity [1,2].

From a veterinary pathology perspective, swine influenza is particularly important because the disease clearly demonstrates the relationship between viral infection, respiratory epithelial injury, inflammation and secondary infection. The lungs provide valuable evidence of this interaction through characteristic gross and microscopic changes. Understanding these lesions helps the pathologist interpret the clinical picture, select appropriate samples and distinguish

uncomplicated influenza from complicated respiratory disease.

The Causative Virus: Influenza A and Its Biological Characteristics

Influenza A viruses belong to the family Orthomyxoviridae and possess an enveloped, segmented, negative-sense, single-stranded RNA genome. Haemagglutinin (HA) and neuraminidase (NA) are major surface glycoproteins involved in viral attachment and release and are important determinants of subtype. The segmented genome also permits genetic reassortment when different influenza viruses infect the same cell, while replication errors contribute to antigenic variation [2,3]. In swine, H1N1, H1N2 and H3N2 lineages are important circulating influenza A subtypes, although their genetic and antigenic characteristics vary geographically [2].

Pathogenesis: From Viral Entry to Respiratory Injury

The respiratory tract is the primary site of infection. Transmission occurs mainly through respiratory secretions, droplets or aerosols, direct pig-to-pig contact and contaminated materials. After inhalation, virus reaches the respiratory epithelium and replicates in susceptible epithelial cells. Viral replication causes cellular degeneration, necrosis and desquamation, particularly within bronchial and bronchiolar epithelium. Loss of ciliated cells is especially important because cilia are central to mucociliary clearance. When this defence is impaired, mucus and microorganisms remain in the respiratory tract for longer periods, increasing the opportunity for secondary infection [1].

The pathological sequence can be summarized as: viral infection → epithelial degeneration and necrosis → loss of ciliated cells → impaired mucociliary clearance → inflammatory response → pulmonary injury → increased susceptibility to secondary infection. In the acute form, viral replication and epithelial injury can develop rapidly, with gross pulmonary lesions becoming evident during the early phase of infection [1].

Clinical Manifestations: The First Signs of Respiratory Disease

Clinical disease commonly appears suddenly and can spread rapidly through a susceptible group. Affected pigs may develop fever, depression, anorexia, coughing, sneezing, nasal discharge, weakness and, in more severe

cases, dyspnoea. Uncomplicated infections may resolve within several days, but coinfections or secondary bacterial infections can prolong disease and increase production losses [1]. A sudden increase in coughing and fever affecting many animals over a short period is an important epidemiological clue during outbreak investigation.

Gross Pathology: What the Pathologist Sees at Necropsy

The lungs provide some of the most useful pathological information in suspected cases. In uncomplicated influenza A infection, affected areas are generally clearly demarcated, collapsed and purplish red. Lesions may be patchy throughout the lungs but tend to become more extensive and confluent ventrally, with prominent involvement of apical and middle lobes. The affected tissue is firmer than normal lung and may appear depressed. Airways may contain copious mucous or mucopurulent exudate, while bronchial and mediastinal lymph nodes can be oedematous [1]. Pulmonary oedema or serous to serofibrinous pleuritis may also occur.

These gross lesions are valuable diagnostic clues but are not pathognomonic for influenza. Similar patterns of consolidation can occur with other viral, bacterial and mycoplasmal respiratory diseases. Therefore, gross pathology should always be interpreted together with clinical information and laboratory testing.

Histopathology: Looking Beyond the Gross Lesion

Microscopic examination provides a more detailed view of disease development. Fully developed lesions are characterized primarily by exudative bronchiolitis with an interstitial component. Bronchiolar epithelial cells may show swelling, degeneration and necrosis, with loss and desquamation of ciliated epithelium. Degenerated cells and inflammatory exudate can accumulate within bronchiolar lumina. Inflammatory cells, including macrophages, neutrophils and lymphocytes, may be present depending on the stage and severity of infection [1].

Adjacent alveolar septa may become thickened because of inflammatory cell infiltration and oedema, while alveolar spaces may contain macrophages, neutrophils, proteinaceous material and cellular debris. These changes impair gas exchange and contribute to respiratory distress. During recovery, epithelial regeneration may

become prominent as surviving cells proliferate and restore the bronchiolar lining.

Inflammation: A Double-Edged Response

Inflammation is an essential component of the host response to influenza virus infection. Viral components and damaged epithelial cells stimulate inflammatory mediators and recruit immune cells to the respiratory tract. Macrophages and other inflammatory cells participate in removal of damaged tissue and infectious material. However, excessive or prolonged inflammation can itself contribute to pulmonary injury. Thus, the final lesion reflects both direct viral damage and the host inflammatory response.

Secondary Bacterial Infection: When Influenza Opens the Door

One of the most important complications of influenza is secondary bacterial infection. Damage to respiratory epithelium and loss of mucociliary clearance allow bacteria to persist and multiply more easily. Coinfections involving organisms such as *Mycoplasma hyopneumoniae*, *Actinobacillus pleuropneumoniae* and other respiratory pathogens are recognized in the porcine respiratory disease complex [1,2]. Secondary infection may produce more severe bronchopneumonia, fibrinous pneumonia, pleuropneumonia or systemic complications. Consequently, severe lesions should not automatically be attributed to influenza virus alone.

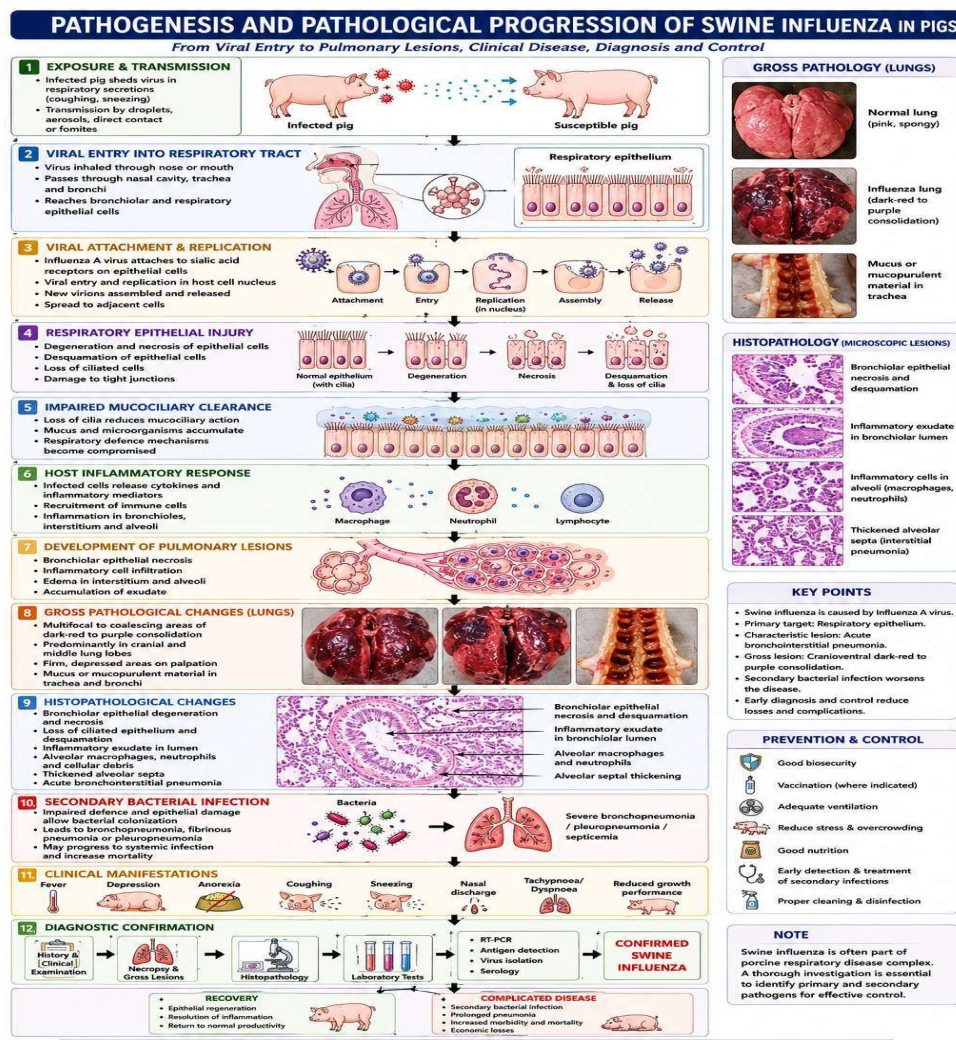


Fig. 1: Pathogenesis and Pathological Progression of Swine Influenza in Pigs. Source: AI-generated schematic based on the pathological and diagnostic framework described in references [1–3].

Diagnostic Approach: Integrating Pathology with Laboratory Confirmation

A reliable diagnosis requires integration of clinical history, epidemiological information, gross pathology, histopathology and laboratory findings. During necropsy, the respiratory tract should be examined systematically, and the distribution, colour, consistency and extent of pulmonary lesions should be recorded. Appropriate respiratory swabs and affected tissues should be collected early in disease for laboratory testing.

Real-time reverse transcription polymerase chain reaction (rRT-PCR) is an important method for detecting influenza A viral RNA, while virus isolation can provide additional confirmation and material for characterization. Histopathology demonstrates tissue-level injury, and immunohistochemistry or other antigen-detection methods may help localize viral antigen in affected tissues. The strongest diagnosis is obtained when the pathological findings are consistent with the clinical history and supported by laboratory evidence [1].

Differential Diagnosis: Not Every Consolidated Lung Is Influenza

Several respiratory diseases can produce similar clinical and pathological findings. Important differential diagnoses include infections associated with *Mycoplasma hyopneumoniae*, *Actinobacillus pleuropneumoniae*, *Pasteurella multocida* and porcine reproductive and respiratory syndrome virus. The pathologist should consider lesion distribution, the character of pulmonary exudate, the presence or absence of pleuritis and the microscopic pattern. Because mixed infections are common, detection of one pathogen does not necessarily exclude another [1].

The Role of the Veterinary Pathologist in Swine Influenza

The veterinary pathologist plays a central role in respiratory disease investigation. A practical diagnostic sequence is: clinical history → necropsy examination → gross lesion interpretation → histopathology → molecular or antigen detection → differential diagnosis → final pathological interpretation. The objective is not merely to identify a lesion, but to explain the disease process, recognize complications and assess the contribution of secondary pathogens. This integrated approach is especially valuable in herd outbreaks, where a single pathogen may not explain the entire clinical and pathological picture.

Prevention and Control: Looking Beyond Treatment

Control requires a herd-level approach. Good biosecurity, controlled movement of pigs and people, quarantine procedures, appropriate cleaning and disinfection, adequate ventilation and avoidance of overcrowding can reduce transmission and respiratory stress. Good nutrition and reduction of unnecessary stress are also important. Vaccination is an important tool for influenza control, but its effectiveness depends on the antigenic match and herd circumstances; it should therefore be combined with sound management and surveillance rather than treated as a substitute for biosecurity [2,3]. Secondary bacterial infections should be investigated and managed under veterinary guidance.

One Health Perspective: Why Swine Influenza Matters Beyond the Farm

Swine influenza has importance beyond individual animal health. Pigs can be infected with influenza viruses from different host species, and the segmented influenza A genome permits genetic reassortment during coinfection. This contributes to viral diversity and makes surveillance in swine populations important for animal and public health. The role of pigs in influenza ecology is therefore best considered within a One Health framework, while avoiding the assumption that every swine influenza virus has the same zoonotic potential [2].

Conclusion: The Lung as a Window Into Disease

Swine influenza is a complex respiratory disease in which viral infection, epithelial injury, inflammation, impaired mucociliary defence and secondary infection interact to determine the final pathological outcome. For the veterinary pathologist, the disease becomes clearer when clinical history is integrated with systematic necropsy and microscopic examination. Characteristic purplish-red pulmonary consolidation provides an important gross clue, while bronchiolar epithelial degeneration and necrosis, inflammatory changes and bronchointerstitial lesions reveal the underlying tissue response.

Pathology alone, however, should not be considered sufficient for definitive diagnosis. Molecular or antigen detection should be used to confirm the infectious agent, particularly because other respiratory pathogens can produce

overlapping lesions and mixed infections are common. A pathology-oriented approach therefore helps move the diagnosis from simply naming a disease to understanding how the disease developed, why lesions became severe and how secondary infections contributed to the outcome.

Effective control depends on viewing swine influenza as a complete biological

process—from viral entry and epithelial injury to inflammation, pulmonary lesions, secondary infection and recovery. This integrated understanding can improve diagnostic sampling, outbreak investigation, herd management and disease control, while supporting healthier and more productive swine populations.

References

1. MSD Veterinary Manual. Influenza in Pigs (Hog Flu, Pig Flu, Swine Flu). Reviewed July 2026. Merck & Co., Inc.; 2026.
2. Mancera Gracia JC, Pearce DS, Masic A, Balasch M. Influenza A Virus in Swine: Epidemiology, Challenges and Vaccination Strategies. *Front Vet Sci.* 2020;7:647. doi:10.3389/fvets.2020.00647.
3. Salvesen HA, Whitelaw CBA. Current and prospective control strategies of influenza A virus in swine. *Porcine Health Manag.* 2021;7:23. doi:10.1186/s40813-021-00196-0.

Note: AI-generated flow diagram; scientifically reviewed by the authors.

Cite this article:

Sourabh Babu, Vivek Kumar, Chandrakanta Jana, Rajveer Singh Pawaiya, Sanjay Kumar Yadav and Mahesh Kumar. (2026). Swine Influenza: Pathobiology, Pulmonary Lesions, Diagnosis and Its Significance in Porcine Respiratory Disease. *The Scientific Frontiers*, 03(08), 1–5. <https://doi.org/10.5281/zenodo.22774222>