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Porcine semen as a vector for transmission of viral pathogens

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ABSTRACT

Different viruses have been detected in porcine semen. Some of them are on the list of the World Organization for Animal Health (OIE), and consequently, these pathogens are of socioeconomic and/or public health importance and are of major importance in the international trade of animals and animal products. Artificial insemination (AI) is one of the most commonly used assisted reproductive technologies in pig production worldwide. This extensive use has enabled pig producers to benefit from superior genetics at a lower cost compared to natural breeding. However, the broad distribution of processed semen doses for field AI has increased the risk of widespread transmission of swine viral pathogens. Contamination of semen can be due to infections of the boar or can occur during semen collection, processing, and storage. It can result in reduced semen quality, embryonic mortality, endometritis, and systemic infection and/or disease in the recipient female. The presence of viral pathogens in semen can be assessed by demonstration of viable virus, nucleic acid of virus, or indirectly by measuring serum antibodies in the boar. The best way to prevent disease transmission via the semen is to assure that the boars in AI centers are free from the disease, to enforce very strict biosecurity protocols, and to perform routine health monitoring of boars. Prevention of viral semen contamination should be the primary focus because it is easier to prevent contamination than to eliminate viruses once present in semen. Nevertheless, research and development of novel semen processing treatments such as single-layer centrifugation is ongoing and may allow in the future to decontaminate semen.

1. Introduction

Artificial insemination (AI) is one of the most commonly used assisted reproductive technologies in pigs. It has been carried out for more than 40 years and is currently widely practiced in almost all intensive pig production systems. For more than 2 decades, more than 90% of the sows have been bred by AI in most European countries [1]. Also in North America and in important pig producing countries of Latin America, AI has reached levels of approximately 90%. A significant increasing trend is also discernible in several East Asian countries, e.g., 50% of the sows are artificially inseminated in modern farms in the Philippines. In Thailand and Taiwan, more than 70% of the sows are currently artificially inseminated [2].

There are several factors that may explain the broad application of AI [3]. Compared to natural mating, there is an accelerated propagation and amplification of genetic merit, there are economic savings, and the reproductive management is easier. In addition, as there is no copulation and no direct physical contact between the boar and

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the sow, the risk for introduction or transmission of boar pathogens in the sow herd is lower. However, in the case of AI, one ejaculate is processed and diluted to produce several insemination doses that are subsequently sold to many different sow farms. If pathogens are present in the semen, they may initiate infection of the sow, and consequently, AI is associated with an increased risk for quick and widespread transmission of these pathogens. Consequently, although the risk for disease transmission after AI may be minimal, the impact of semen that is contaminated with pathogens can be enormous, especially if a large number of sow herds are involved.

It is well known that ejaculated porcine semen may contain different microbes. They can be either from animal or nonanimal origin [4]. Contamination by microbes of animal origin can be due to general or local infections within the boar, and shedding through the testes and other tissues of the genital tract. Contamination can also originate from preputial cavity fluids, respiratory secretions, and fecal particles during collection and processing. Contamination of nonanimal origin mostly originates from the person collecting the semen (hair, skin, respiratory secretions); from the water used during semen processing, the ventilation system, and aerosols; and from sinks/drains [5].

Microbial contamination may include pathogens causing specific disease conditions, or microorganisms that are not considered as pathogens. Boar ejaculates usually contain 10^4 to 10^5 bacteria/mL [6]. Most of them are nonpathogenic for the animal, but they may however impair sperm quality [5]. Specific bacterial pathogens in porcine semen include *Brucella suis*, *Leptospira* spp., *Mycobacterium* spp., *Chlamydia* spp., and *Mycoplasma spp*. Unlike bacterial pathogens, there are numerous viral pathogens that can be found in porcine semen. The present article will review the most important viruses found in porcine semen used for AI, the impact they may have, diagnostic procedures, and control measures that can be applied to limit or prevent contamination of semen used for AI.

2. Viruses in porcine semen

Different viruses have been detected in porcine semen. Some of them are on the list of the World Organization for Animal Health (OIE 2015; Tables 1 and 2), and consequently, these pathogens are of socioeconomic and/or public health importance within countries and are of major importance in the international trade of animals and animal products. This implies that major trade restrictions are in place for semen contaminated with pathogens in the OIE list. Other viruses found in porcine semen are not in the OIE list (Tables 3 and 4) but may also cause disease and major economic losses to the pig industry worldwide or in specific areas. The period during which viruses can be detected in the semen using different diagnostic tests is shown in Table 1 for viruses of the OIE list and in Table 3 for viruses not in the OIE list. The impact of these viruses on semen quality and transmission to the sow after AI is shown in Tables 2 and 4, respectively.

The different viruses in the present article are discussed in alphabetical order as it is difficult to rank them precisely on the basis of importance. Some viruses such as porcine cytomegalovirus, bovine viral diarrhea virus (BVDV), border disease virus, torque teno virus, and pig endogenous retroviruses (PERVs) are not considered to be very important in pigs. The importance of some recently identified viruses (e.g., *Reston ebolavirus* [REBOV], novel parvoviruses such as porcine parvovirus type 4 [PPV4]) is not yet clearly established. Some viruses are only important in specific geographical areas, e.g., Japanese encephalitis virus and rubulavirus. The worldwide importance of other viruses such as Aujeszky's disease virus (ADV), classical swine fever (CSF) virus, foot-and-mouth disease (FMD) virus, and porcine reproductive and respiratory syndrome virus (PRRSV) is well known.

Table 1
Viral pathogens from the OIE list (2015) that have been found in porcine semen: boar infection type and timing of detection (test used).

Virus	Boar infection type	Timing of detection (test used)	Reference
African swine fever virus	Experimental	Not mentioned	Schlafer 1984, mentioned in [7]
Aujeszky's disease virus	Natural	Detected (virus isolation)	[8]
	Experimental	Detected (virus isolation)	[9]
Classical swine fever virus	Experimental	7 and 11 DPI (virus isolation)	[10]
	Experimental	7–63 DPI (RT-PCR); 11, 18, 21, and 53 DPI (virus isolation)	[11]
Foot-and-mouth disease virus	Exposed to experimentally inoculated pen-mates	Up to 9 days after exposure (virus isolation)	[12]
Japanese encephalitis virus	Experimental	35 DPI (virus isolation)	[13]
Porcine reproductive and respiratory syndrome virus	Experimental	2–57 DPI (nested PCR)	[14]
		12–21 DPI (nested RT-PCR)	[15]
		Up to 47 DPI (nested RT-PCR)	[16]
		Up to 92 DPI (nested RT-PCR)	[17]
		7 and 8 DPI (swine bioassay seroconversion)	[18]
		43 DPI (swine bioassay seroconversion)	[16]
		Up to 43 DPI (swine bioassay seroconversion and virus isolation)	[19]
		7 DPI (virus isolation)	[14,20]
		11 DPI (virus isolation)	[16]
Swine vesicular disease virus	Exposed to experimentally inoculated pen-mates	Up to 4 DPI (virus isolation)	[12]

Abbreviations: DPI, days post inoculation; PCR, polymerase chain reaction; RT-PCR, reverse transcriptase polymerase chain reaction.