

Pathogens that cause infertility of bulls or transmission via semen

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Abstract

The purpose of this paper is to review scientific evidence regarding pathogens that cause infertility of bulls or that could be transmitted via bovine semen. Although several pathogens can cause male infertility and potentially be transmitted via semen, adhering to disease control recommendations provided by Certified Semen Services (CSS) and the World Organization for Animal Health (OIE) can prevent infectious male infertility and ensure that the risk of pathogen transmission via semen is negligible. Regarding bulls to be used for natural breeding, quarantine prior to herd introduction and appropriate diagnostic testing during quarantine will commonly prevent introduction of pathogens that adversely affect reproduction.

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Keywords: Pathogen; Infertility; Semen; Bovine; Bull

1. Introduction

Bulls are essential for reproductive efficiency to facilitate production of meat and milk. Whether used for natural breeding or as the donor of cryopreserved semen, bulls can introduce pathogens as well as male gametes into the reproductive process. Determinants of the potential for pathogens to cause male infertility or disease transmission include infectivity, virulence, prevalence, and thermal stability of the agent, as well as the length of the incubation period, the length of the infectious period, and the number of contacts with susceptible animals. The purpose of this paper is to

review scientific evidence regarding pathogens that cause infertility in bulls or that could be transmitted via bovine semen. Disease control measures that result in negligible risk of pathogen transmission are emphasized. Previous reviews, which focus on subsets of information within this topic, are excellent sources for additional scientific detail [1–4].

2. Pathogens that cause infertility in bulls or transmission via semen

Several pathogens can lead to infertility in bulls or result in transmission via semen. For the purpose of this review, pathogens have been categorized as viral, bacterial, or protozoal agents. Some of these pathogens can directly affect bull fertility by causing disease of the reproductive tract or associating with spermatozoa to prevent fertilization.

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2.1. Viral pathogens

Two important viral pathogens that can be transmitted via semen are bovine herpesvirus 1 (BoHV-1) and bovine viral diarrhea virus (BVDV). Bovine herpesvirus 1 can cause clinical disease of the male reproductive tract (infectious balanoposthitis) [2], and it can also associate with spermatozoa [5–8]. The virus replicates in the mucosa of the prepuce, penis, and distal urethra, and can be present in the seminal plasma of infected bulls [6,9–13]. Although BoHV-1 does not affect sperm motility or acrosomal status [9], others have described an affect on semen quality, most likely due to generalized illness rather than a direct effect of the virus on the spermatozoa [6,10,14]. The virus can inhibit sperm-zona binding by interacting with spermatozoa [9]. Bovine herpesvirus-1 can be transmitted through semen and result in infection, reduced conception rates, endometritis, abortion, and infertility [14,15]. Once infected, bulls may shed the virus in semen throughout life [14]. Conversely, there are indications that semen from BoHV-1 seropositive bulls can be free of virus for prolonged intervals if bulls are well managed in a low-stress environment [16].

Another important reproductive pathogen, BVDV, replicates in the seminal vesicles, prostate gland, and epididymis of the bull [17]. As well, BVDV antigen has been detected in the epithelial cells of the ductus epididymis, accessory glands, urethra, Sertoli cells, and spermatogonia [18]. Prolonged testicular infection can occur, with detection of virus in testicular tissue for 7 mo following an acute infection [19]. Although BVDV can be shed in semen, acute or persistent infections may or may not affect semen quality [17,20]. Heifers inseminated with semen from an acutely or persistently infected bull can become infected [21–23]. Reduced conception rates, production of persistently infected calves, or birth of clinically normal offspring may result from insemination with contaminated semen [1,20]. That BVDV has varying effects on fertility may be due to strain differences [1].

Other viruses that can be transmitted in semen include foot-and-mouth disease virus, vesicular stomatitis virus, rinderpest virus, and lumpy skin disease virus [4,24]. The risk of transmitting bovine immunodeficiency virus and bovine leukosis virus via semen appears to be very low [2,25–27]. Bluetongue virus can be detected sporadically in the semen of viremic bulls and might result in viral transmission [2,3].

2.2. Bacterial and protozoal pathogens

Tritrichomonas foetus and *Campylobacter fetus venerealis* are sexually transmitted diseases that do not cause disease in the bull [28,29]. These organisms reside on the epithelium of the preputial cavity of infected bulls; with increasing age, the epithelial crypts of the prepuce become deeper, providing a microaerophilic environment that supports replication of these microbes. Thus, a bull can develop a life-long infection. Although these organisms are generally associated with the glans penis and proximal prepuce, semen can become contaminated. *T. foetus* and *C. fetus venerealis* can survive cryopreservation of semen [29]. Trichomonads adhered to spermatozoa causing sperm agglutination, a decrease in sperm motility, and phagocytosis of sperm [30]. Transmission of *T. foetus* or *C. fetus* to the female can result in vaginitis, cervicitis, endometritis, infertility, delayed return to estrus, early embryonic death, and rarely abortion (up to 4 mo of gestation, *T. foetus*; 4–7 mo of gestation, *C. fetus*) [28,29]. Occasionally, postcoital pyometra can result from uterine infection. Unlike infections in the bull, a humoral immune response commonly clears infections of the female reproductive tract within 90 d.

Brucella abortus can also localize in the reproductive tract of the bull [31]. The cells of the genital tract contain high concentrations of erythritol that enhance the growth of this zoonotic pathogen. Infection can lead to orchitis, epididymitis, seminal vesiculitis, ampullitis, decreased libido, and infertility. The organism can also be present in semen.

Other bacteria can be transmitted in semen and might be associated with infertility or transmission of the disease. Furthermore, several of the organisms are infectious following cryopreservation of semen. *Leptospira* spp. can be isolated from the genital tract of subclinical bulls and transmitted in semen [28]. The organism can also survive cryopreservation. *Histophilus somnus* can be isolated from the reproductive tract of normal bulls and be present in semen [32]. Although the organism is sensitive to antimicrobials, it is not known if transmission via processed semen would result in infection of susceptible cows. Likewise, *Ureaplasma diversum* can be transmitted in semen and induce endometritis, salpingitis, and cervicitis, but can also be isolated from unaffected animals [28]. *Mycobacterium avium* subsp. *paratuberculosis* can also be present in the semen of subclinical bulls [33]. The organism is capable of surviving antibiotics and cryopreservation. Additionally, *Chlamydia* can cause infection of the reproductive tract of the bull [34]; it can be present

in semen and survive cryopreservation. Other organisms which might be transmitted via semen include *Mycobacterium bovis*, *Coxiella burnetii*, and *Mycoplasma mycoides* ssp. *mycoides* [4,35].

3. Disease control

The World Organization for Animal Health (OIE) has standards for disease control associated with semen production (Appendix 3.2.1 of the OIE Terrestrial Animal Health Code) [36]. These requirements allow for the transport of semen, with a negligible risk of pathogen transmission via the semen. While not required, these recommendations provide idealistic guidelines for the introduction of a new bull into any herd. The animals are to be clinically healthy and undergo testing pre-quarantine, during quarantine, and as residents of the semen collection facility [36]. Pre-quarantine testing should confirm the bull to be free of brucellosis, tuberculosis, BVDV, as well as BoHV-1 if the herd or AI center is to be considered BoHV-1-free. Additionally, Certified Semen Services (CSS; http://www.naab-css.org/about_css/) recommend that bulls be tested for *Leptospira* [37]. Quarantine should commence for at least 28 d. During this interval, bulls should be tested and confirmed negative for brucellosis, BVDV, *T. foetus*, *C. fetus*, and BoHV-1 if the herd or AI center is to be considered BoHV-1-free. Residents of the semen collection facility should be annually tested for brucellosis, tuberculosis, BVDV, *T. foetus*, *C. fetus*, and BoHV-1. If the AI center is not BoHV-1-free, the frozen semen should be tested for the virus. If a bull develops antibodies against BVDV, his semen should be tested or discarded. Bulls can shed BVDV in semen while being non-viremic [1,38].

Diagnostic tests on semen have limitations due to virucidal properties, cell culture cytotoxicity, and inhibition of reverse transcriptase enzyme of seminal plasma of raw (neat) semen [1]. However, improved analytical sensitivity can be obtained through dilution with semen extenders and use of polymerase chain reaction [39]. In addition to the health of the animal, good hygiene is required for collection, processing and storing semen [36,37]. Gentamicin, tylosin, lincomycin and spectinomycin are commonly added to extended bovine semen prior to cryopreservation to control bacterial contamination.

4. Conclusion

Although several pathogens can cause male infertility and potentially be transmitted via semen,

adhering to disease control recommendations provided by CSS and the OIE can prevent infectious male infertility and ensure that the risk of pathogen transmission via semen is negligible. In cases where particular pathogens are of concern, quarantine of bulls prior to herd introduction and appropriate diagnostic testing during quarantine will commonly prevent pathogen introduction.

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