Case Report

Colloidal silver nanoparticles induced detached sperm heads in a dog

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Abstract

We describe a sperm abnormality (detached heads) in a dog treated with a topical (spray) medication containing colloidal silver nanoparticles (AgNP). However, sperm morphology and fertility recovered 5 months after withdrawal of treatment. To our knowledge, this is the first report of an association between AgNPs and abnormal canine sperm.

Keywords: Dog, fertility, sperm, silver nanoparticles

Background

AgNP is a suspension of microscopic silver particles, also called silver nanoparticles (typically 1-100 nm), used in therapeutic agents and drug delivery systems due to its antimicrobial and antinflammatory properties. However, adverse effects of AgNP on male reproductive function have been described, including reduced sperm count, motility, membrane integrity, and acrosome integrity.[1-3] Absorbed AgNPs can migrate to testes,[2] suggesting a direct contribution to impaired reproductive function and fertility. The proposed toxic effect of AgNPs is release of highly reactive silver ions[4] decreasing defense against oxidative stress and causing cellular damage.

Case presentation

A 3-year intact Great Dane with previously normal semen characteristics and fertility was presented for semen collection and evaluation. The owner reported that 2 months prior to presentation the dog had a flank injury and developed dermatitis (near the tail and scrotum) that was successfully treated with topical antibiotic-based cream (triple antibiotic and nitrofurazone) for ~ 1 month, followed by a topical AgNP-based spray (0.999 pure silver particles in 30 ppm distilled water; Chris Christensen, Peace & Kindness, Fairview, TX, USA) until 1 month before presentation. No changes were reported in dog's diet or routine before or after the injury. At 4 months before injury, semen characteristics included 1.98 x 10^9 sperm, 95% progressive motility and 90% morphologically normal sperm that resulted in a successful pregnancy.

At presentation, the dog appeared healthy; scrotum and scrotal content, and external reproductive tract were normal. Semen was collected by digital stimulation, with NucleoCounter SP-100 system for sperm concentration, phase contrast microscopy for sperm motility, and eosin-nigrosin stain and 1,000 x magnification light microscopy for sperm morphology. Total number of sperm was 1.36 x 10^6 with 80% progressive motility and 32% morphologically normal sperm. The main morphological abnormality was 55% detached heads that suggested either prolonged sexual rest, inflammation from prior scrotal dermatitis, or lesions on scrotal contents and/or ducts.

At 5 months after topical AgNP-based spray treatment, the dog was still apparently healthy and skin injuries were resolved. Semen was successfully collected on 2 visits, 4 days apart and there was no apparent change in the ejaculation or libido. However, for the 2 ejaculates there were 1.0 and 1.5 x 10^9 sperm, 5 and 10% progressive motility, and 90 and 96% morphologically defective sperm, respectively. The main morphological defect was detached heads, accounting for 85 and 85% of total sperm, respectively.

Differential diagnoses included prolonged sexual rest, spermatogenesis affected by inflammation (scrotal dermatitis or flank injury), or possible injury of scrotal contents and/or ducts. However, no gross changes were detected in reproductive tract palpation, ultrasonography or visual inspection. Therefore, the AgNP-based spray was considered the top differential diagnosis. Additionally, despite being a topical medication, owner reported that the dog was accidentally ingesting the AgNP-based spray by licking the area immediately after treatment. The owner was recommended to discontinue the topical AgNP-based spray and schedule semen collection and analysis at least 2 months after drug withdrawal.

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Outcome

Semen evaluation 5 months after drug withdrawal had improved semen characteristics that included 556 x 10^6 sperm, 70% progressive sperm motility and 80% morphologically normal sperm (with 3% detached heads). Therefore, the semen was used for artificial insemination and resulted in a successful pregnancy. A second evaluation (6 months after drug withdrawal) had 1.36 x 10^9 sperm, 70% progressive sperm motility, and 76% morphologically normal sperm (including 3% detached heads). The ejaculate was frozen and postthaw progressive motility reached only 20%. However, evaluation 1 year after drug withdrawal had a total of 1.6 x 10^9 sperm, 70% progressive sperm motility, and 61% morphologically normal sperm (including 8% detached heads). The ejaculate was frozen and postthaw progressive motility reached 50%.

Discussion

We provided evidence that AgNP-based spray affected semen characteristics in a young stud dog that previously had good semen quality. Owner opted for the use of AgNP-based spray, based on its suggested effectiveness and to prevent long-term use of antibiotic-based cream. The first reproductive sign observed after AgNP toxicity was a sudden decline in sperm quality (detached heads). Detached head sperm can be associated with prolonged sexual rest, testicular degeneration caused by trauma, and/or inflammation of the testes and testicular ducts.[5] However, treatment had to be continued to ensure complete scrotal healing. At 3 months after resolution of the skin trauma dermatitis on the flank and in proximity to the scrotum, semen characteristics were worse. At this evaluation, the dog had been treated for ~ 5 months with topical AgNP-based spray, arousing the suspicion of causing sperm abnormalities, especially due to accidental oral ingestion.

In mammalian males, AgNP has been associated with impaired reproductive functions.[1-3,6-14] In mice, AgNP reduced sperm numbers, increased sperm morphological abnormalities and sperm mortality due to increases in reactive oxygen species.[1,2] Additionally, adding AgNP to frozen-thawed donkey semen decreased various end points (sperm motility, sperm morphology, and integrity of plasma and acrosomal membranes).[3] In male fish, AgNP affected reproduction,[6,7] an environmental risk on fish populations. Conversely, supplementation of semen with AgNP in cattle[8] and pigs[9] did not affect semen quality and it can be used as an antimicrobial additive to reduce antibiotic use. However, AgNP toxicity in male reproduction has been a topic of current interest[10-12] and AgNP affects male human reproduction either by a direct effect on sperm or by causing dysfunction of Sertoli cells.[13,14]

Five months after withdrawal of topical AgNP-based spray, semen characteristics and fertility had recovered, indicating a reversible effect. However, sperm end points (e.g. motility and morphology) were still lower than prior to the injuries and AgNP-based treatment. Nevertheless, it is unknown if the incomplete recovery was due to the injury, treatment, and/or natural aging. In conclusion, we provided evidence that AgNP caused sperm morphological changes (detached heads) and that these changes were mostly reversed after drug withdrawal.

Learning points

- AgNP-based treatment was implicated for sperm with detached heads
- AgNP-based products should be avoided in males intended for reproductive use, due to potential reproductive toxicity
- Adverse effects of AgNP on reproduction are apparently reversible

Authors' contributions and declaration

Authors contributed equally to this work; authors read and approved the final submission.

Conflict of interest

None to report.

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