REPRODUCTIVE BIOLOGY

Effect of gold nanoparticles on spermatozoa: the first world report

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Objective: To evaluate the spermatoxicity of gold nanoparticles.
Design: Experimental study.
Setting: A university in Thailand.
Patient(s): Single-donor fresh semen sample.
Intervention(s): A mixture of gold nanoparticle solution and semen was prepared and further analyzed.
Main Outcome Measure(s): Spermatozoa appearance.
Result(s): After mixing the semen with a gold nanoparticle solution, 25% of sperm were not motile. Penetration of gold nanoparticle into the sperm heads and tails was observed.
Conclusion(s): Spermatotoxicity of the gold nanoparticle can be detected. (Fertil Steril® 2007;■:■–■. ©2007 by American Society for Reproductive Medicine.)

Key Words: Gold nanoparticle, toxicity, spermatozoa

Nanoparticles differ from larger samples of the same material in their chemical and physical properties (1). Although human beings have been exposed to airborne nanosized particles throughout their evolutionary stages, such exposures have increased dramatically over the last century (2). The rapidly developing field of nanotechnology will result in new sources of this exposure, through inhalation, ingestion, skin uptake, and injection of engineered nanomaterials (2). Published studies have shown that inhalation of nanosized materials may be harmful (1). Air pollution research has suggested that particles may be more toxic to cells at the nanoscale (1).

There is only limited knowledge about the toxicity of nanoparticles, including in reproductive medicine—for example, regarding effects on spermatozoa. The objective of this preliminary study was to evaluate the spermatoxicity of gold nanoparticles.

MATERIALS AND METHODS

Semen Sample

We used a single, fresh, donor semen sample from one healthy donor for laboratory analysis. It was collected and transferred according to the published standard procedure in reproductive medicine (3).

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Gold Nanoparticle Solution Preparation

We followed the Turkevich citrate reduction method (4). Nine nanometer-sized gold nanoparticles were produced at a concentration of 44 ppm. The nanoparticles can be stored in the dark at 4°C for more than a month.

Study of the Direct In Vitro Toxicity of Gold Nanoparticle on the Spermatozoa

We prepared a mixture of 500 μL of gold nanoparticle solution and semen. Motility and morphological changes were studied after 15 minutes by using clinical microscopy technique under high power. As a control, motility and morphological changes of spermatozoa were studied without the addition of the gold nanoparticle solution. The studies were performed at the Department of Laboratory Medicine of Chulalongkorn University Hospital (Bangkok, Thailand).

RESULTS

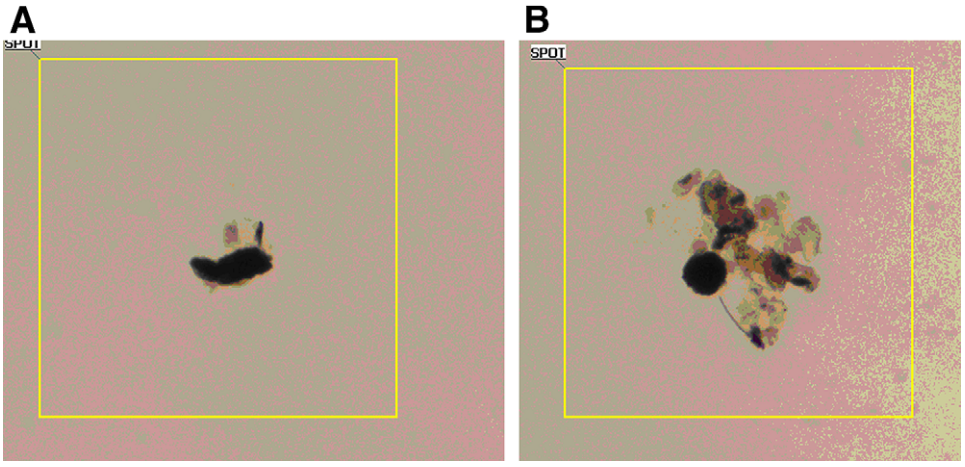
We found that in the semen mixed with the gold nanoparticle solution, 25% of sperm were not motile. The motility of the control sperm was 95%. In the mixture, penetration of gold nanoparticles into the sperm head and tails could be observed. We also noted fragmentation of sperm in the study sample that included the nanoparticle solution (Fig. 1).

DISCUSSION

The effect of environmental contamination on sperm quality is well known. However, the effects of nanoparticles have

FIGURE 1

Change in sperm caused by nanoparticle mixture. (**A**) Staining of the head and tail of sperm. (**B**) Clumping and fragmentation.



Wiwanitkit. Effect of gold nanoparticles on spermatozoa. Fertil Steril 2007.

been elucidated poorly. Ben-David Makhluf et al. (5) performed a study to test the effect of magnetite nanoparticles and found that penetration of magnetite nanoparticles into sperm cells can be visualized. Gold nanoparticles are used widely in industry and science. When gold is in very small particles, with diameters of <10 nm, and is deposited on metal oxides or activated carbon, it becomes surprisingly active. This is particularly true at low temperatures, for many reactions, such as CO oxidation and propylene epoxidation (6). However, no systematic studies of gold nanoparticle spermatoxicity have been reported.

We demonstrated in a preliminary, small study that the motility of spermatozoa was affected by the presence of gold nanoparticles. This differs from the case of magnetite nanoparticles (5). We also noted that gold particles can penetrate sperm cells, which could result in fragmentation. The possible spermatotoxicity of gold in industrial use has been reported elsewhere as a cause of male sterility and, possibly, of epididymitis (7).

We conclude conclusively that spermatotoxicity of the gold nanoparticle can be detected, and this article makes the first report of this. In the present nanomaterial era, the spermatotoxic possibility of other nanoparticles can be further implied.

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