

BACKGROUND

Silver has been used for centuries for its antimicrobial properties in food preservation, water purification, and infection prevention. With the development of nanotechnology, its potential has greatly expanded. Silver nanoparticles (AgNPs), owing to their nanoscale size and large surface area, exhibit enhanced antibacterial activity compared to bulk silver. These properties allow AgNPs to interact effectively with microbial cells, making them potent antimicrobial agents.

AgNPs exhibit broad-spectrum antibacterial activity, even against antibiotic-resistant bacteria. They act through disrupting bacterial cell membranes, generating reactive oxygen species, and interfering with DNA replication and protein synthesis. These multifaceted actions reduce the likelihood of resistance development, making AgNPs a promising alternative in the fight against antimicrobial resistance.

This study explores the use of AgNPs in combating hospital-acquired infections in patients with preeclampsia, a pregnancy-related condition associated with immune dysregulation and increased infection risk that may result in VTE. Our research focuses on antibiotic-resistant bacterial strains, which pose a significant challenge in clinical care.

OBJECTIVES

We investigated the efficacy of AgNPs as antimicrobial agents in managing infections among preeclampsia patients, particularly targeting antibiotic-resistant bacteria commonly found in hospital environments.

METHODS

Silver nanoparticles (~20 nm) were synthesized using a chemical reduction method. Their antibacterial activity was tested using the disk diffusion method against Gram-positive (*Staphylococcus aureus*) and Gram-negative bacteria. Various concentrations of AgNPs were tested alongside standard antibiotics. Synergistic effects were assessed by combining AgNPs with antibiotics. Zones of inhibition were measured in millimeters, and all experiments were performed in triplicate to ensure reproducibility and statistical reliability.

RESULTS

Figure 1 illustrates the potential of silver nanoparticles in medical applications, focusing on their antibacterial properties. The diagram highlights the interaction of silver nanoparticles with bacterial cells, showing their ability to disrupt bacterial membranes and inhibit growth, offering a promising approach for combating infections

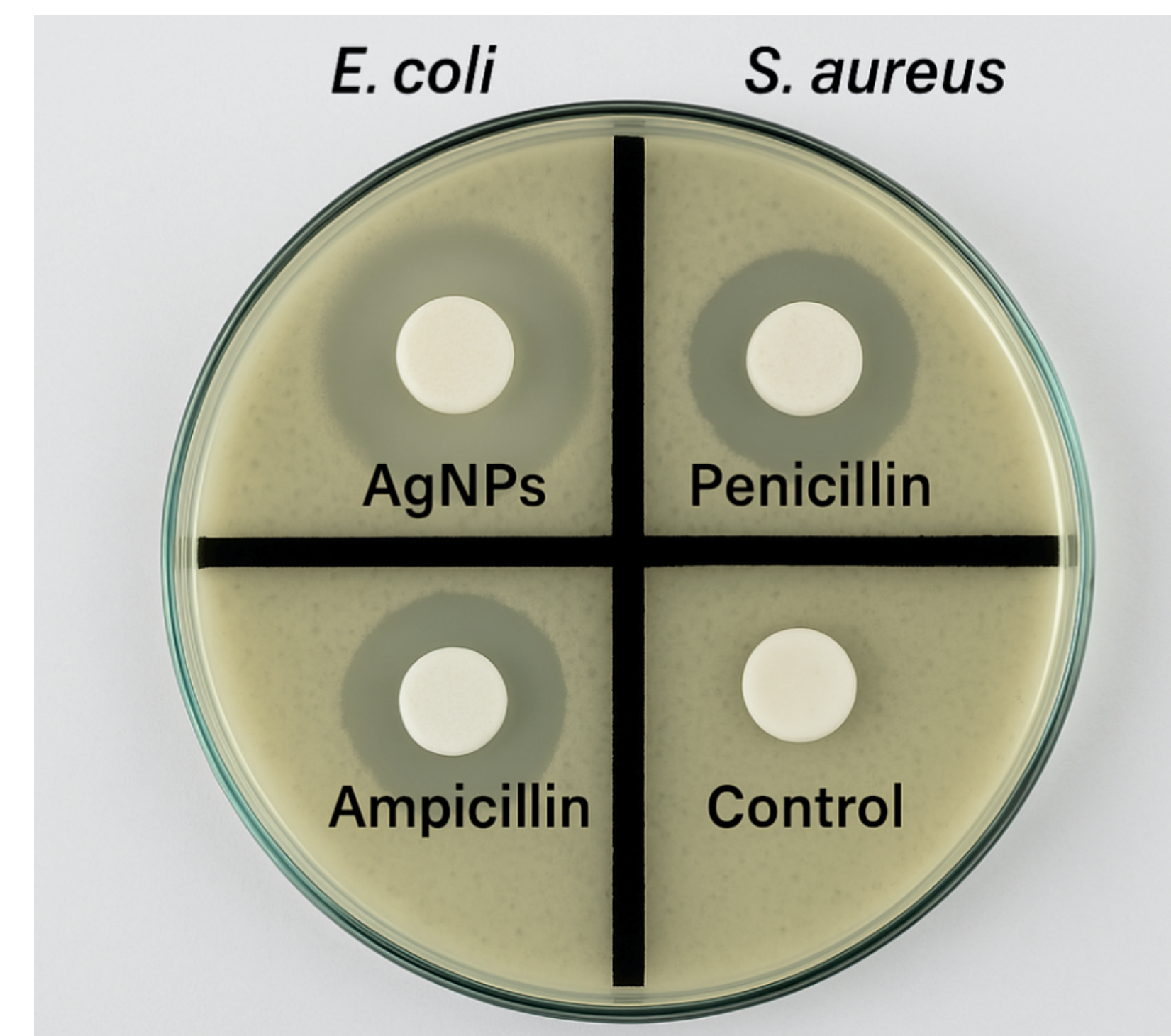


Figure 1. Antibacterial activity of different treatments against *E. coli* and *S. aureus* using an agar diffusion test. The petri dish is divided into four sections containing silver nanoparticles (AgNPs), penicillin, ampicillin, and a control. The clear zones surrounding the disks represent zones of inhibition where bacterial growth was prevented. Larger clear zones indicate stronger antibacterial effectiveness, demonstrating the potential antimicrobial activity of silver nanoparticles compared with standard antibiotics and the untreated control.

AgNPs showed significant antibacterial activity, with higher concentrations yielding larger zones of inhibition in a dose-dependent manner. Notably, they were particularly effective against antibiotic-resistant strains. The antibacterial effect was more pronounced against Gram-negative bacteria compared to Gram-positive bacteria, likely due to differences in cell wall structure. When combined with antibiotics, AgNPs enhanced the antibacterial effect, especially against resistant bacteria, demonstrating a clear synergistic interaction. The combination treatments produced significantly larger inhibition zones than either AgNPs or antibiotics alone ($p < 0.05$). These results indicate that AgNPs not only possess intrinsic antimicrobial properties but can also restore or potentiate antibiotic efficacy against resistant pathogens.

Figure 2 highlights the ways AgNPs kill bacterial cells. AgNPs damage the cell membrane, destabilize ribosomes, and disrupt mitochondrial function. They also inhibit the electron transport chain, generating reactive oxygen species that cause oxidative stress. This leads to DNA and protein damage, ultimately resulting in bacterial cell death. These mechanisms make AgNPs effective antimicrobial agents, particularly against resistant bacteria.

RESULTS CONT.

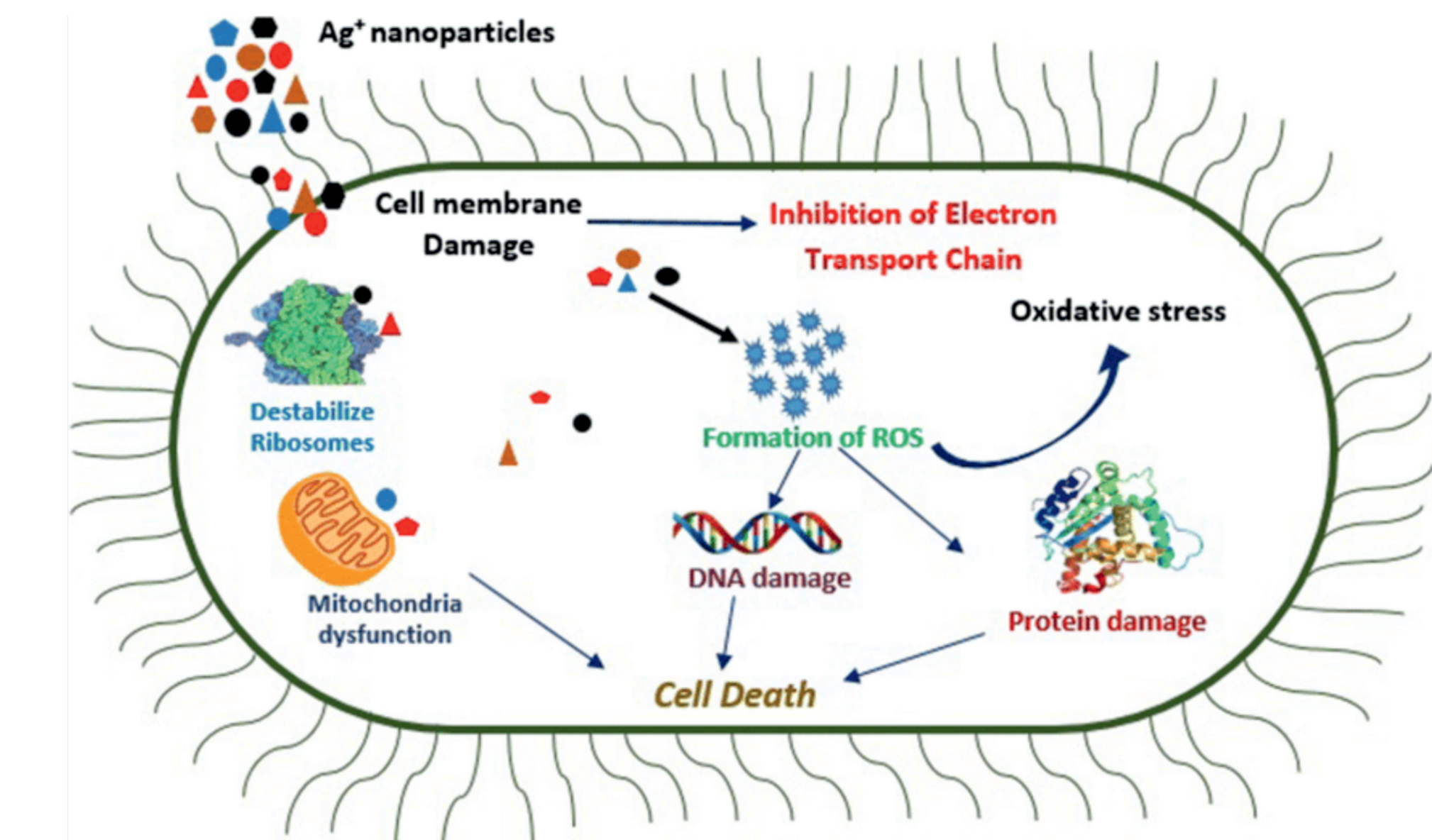


Figure 2. Mechanism of antibacterial action of silver nanoparticles (AgNPs). AgNPs interact with bacterial cells by damaging the cell membrane, destabilizing ribosomes, and disrupting mitochondrial function. They inhibit the electron transport chain and stimulate the formation of reactive oxygen species (ROS), leading to oxidative stress. These processes cause DNA and protein damage, ultimately resulting in bacterial cell death.

CONCLUSIONS

Silver nanoparticles offer a promising alternative to traditional antibiotics, particularly amid the growing threat of antibiotic resistance. Their ability to act through multiple antibacterial mechanisms makes them effective against a broad range of pathogens, including resistant strains. Our findings support the potential use of AgNPs to manage bacterial infections in preeclampsia patients at risk of VTE, for whom traditional treatments may be less effective.

While results are encouraging, further research is necessary to evaluate long-term safety, toxicity, environmental impact, and regulatory considerations. Addressing these challenges is crucial before AgNPs can be widely implemented in clinical settings. If proven safe and effective, silver nanoparticles could play a key role in managing future infections in patients with preeclampsia who may develop VTE

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