PHILIPPINE JOURNAL OF
Ophthalmology
VOL. 32 • NO. 1 JANUARY - JUNE 2007

ORIGINAL ARTICLE

Antimicrobial potency of colloidal silver compared with antibiotic eye drops

Dean D. Concepcion, MD
Lee G. Verzosa, MD
Jose Jurel M. Nuevo, RMT, MA

Fatima Eye Center
Fatima Medical Center
Valenzuela City, Philippines

ABSTRACT

Objectives

This study determined the antimicrobial potency of colloidal silver against *Escherichia coli, Staphylococcus epidermidis, Staphylococcus aureus,* and *Bacillus subtilis* compared with that of tobramycin, lomefloxacin, and moxifloxacin eye drops.

Methods

Three concentrations of colloidal silver (10, 20, and 30 ppm) were impregnated in filter paper discs placed on the surface of agar inoculated with test organisms, namely, *Escherichia coli, Staphylococcus epidermidis, Staphylococcus aureus,* and *Bacillus subtilis.* Antibacterial-activity testing (ABAT) and Kirby Bauer disc diffusion were employed to test the antimicrobial potency of colloidal silver against ophthalmic antibiotics (tobramycin, lomefloxacin, and moxifloxacin). Resulting zones of inhibition of the antimicrobials tested were compared with those of the control antibiotic ampicillin. Sensitivity and resistance of the different pathogens were determined.

Results

Twenty-two-millimeter zones of inhibition in the Kirby Bauer were observed in the 30 ppm preparation of colloidal silver for both *S. aureus* and *B. subtilis,* showing strong inhibitory activity compared with ampicillin (16 mm and 10 mm respectively). A 12-mm zone of inhibition was measured for *S. epidermidis,* showing slight inhibitory activity. ABAT showed that *E. coli, S. epidermidis, S. aureus,* and *B. subtilis* were resistant to the different concentrations of colloidal silver but sensitive to ampicillin, tobramycin, lomefloxacin, and moxifloxacin.

Conclusions

Kirby Bauer disc-diffusion test demonstrated that *S. epidermidis, S. aureus,* and *B. subtilis* were sensitive to the 30-ppm concentration of colloidal silver. On the other hand, ABAT yielded negative results for colloidal silver at 10, 20, 30 ppm when tested against these organisms.

Correspondence to
Dean D. Concepcion, MD
Fatima Eye Center
Fatima Medical Center
120 Mc Arthur Highway
1440 Valenzuela City, Philippines
Telephone : +63-917-9318230
E-mail : dean_concepcion@yahoo.com

No financial assistance was received for this study.

The authors have no proprietary or financial interest in any product used or cited in this study.

Keywords: *Colloidal silver, antimicrobial, alternative medication, culture*

PHILIPP J OPHTHALMOL 2007; 32(1): 9-11

SINCE the early 1900s, medical practitioners have used colloidal silver orally, topically, and intravenously as treatment for various conditions caused by viruses, bacteria, and fungi.[1, 2] It has been considered a "cure all" therapy by others.[3, 4] Silver has since been available in different preparations such as silver nitrate for neonatal ophthalmia prophylaxis and silver sulfadiazine for burn injuries.[5, 6] With the advent of more potent antibiotics, silver became less popular. Adverse effects of chronic exposure to silver, like systemic argyria and to some extent ocular argyrosis, have also been noted. This may be due to inferior-quality preparations further contributing to toxicity.[1, 3, 7] In the field of alternative medicine, however, there is a resurgence in the use of colloidal silver. It is now being prescribed for numerous illnesses, including conjunctivitis.

Colloidal silver is composed of nanoparticles of silver suspended in solution. The silver particles are so minute that they are not affected by gravity while evenly dispersed in water.[3] Hence, no sediments are seen in superior-quality colloidal-silver preparations. The particle size of silver is essential, ideally ranging from 0.05 to 0.01microns. The particulate size of silver affects its ability to be absorbed by the body without causing any cell damage to human tissue at low doses. The only adverse effect is argyria. Colloidal silver, the more biologically active form of silver, is readily absorbed by the body.[3]

The mechanism of action of silver on microbes is said to be at the cell-membrane level. It affects the function of membrane-bound enzymes, such as those involved in the respiratory chain, through binding with the thiol groups.[8] Recent electron microscopic studies such as that of Yamanaka, Hara, and Kudo,[8] however, suggest that antimicrobial action occurs within the cell cytoplasm. Silver appears to penetrate through the ion channels without causing cell-membrane damage.[6] Silver denatures the ribosomes and suppresses the expression of enzymes and proteins essential to ATP production, eventually causing cell death.[8]

Despite these studies, there are many conflicting reports on the potency of colloidal silver. Some studies claimed that colloidal silver does not possess any antimicrobial property. In a recent study by Van Hasselt, Gashe, and Ahmad,[9] colloidal silver was tested against similar groups of organisms using well-diffusion (ABAT) and disc-diffusion test (Kirby Bauer). These tests showed no effect on the growth of the test organisms, suggesting that the antimicrobial effect of colloidal silver may be more myth than fact. In this study, we aimed to independently verify these claims.

Table 1. **Data comparison for sensitivity and resistance of bacteria.**[1]

Inhibitory Action	Zone of Inhibition	Interpretation
++++	>/=22mm	Strong inhibitory action
+++	18-21mm	Complete inhibitory action
++	14-17mm	Partial inhibitory action
+	</=13mm	Slight inhibitory action
0	No Zone	No inhibitory action

[1]National Committee for Clinical Laboratory Standards (NCCLS, 2001)

METHODS

A stock solution of colloidal silver (30 parts per million, ppm) was used for this study. This stock solution was diluted with sterile water to produce 20, and 10 ppm colloidal-silver preparations. To preserve the silver in its particulate state, these were stored in capped, sterile, amber-colored bottles, avoiding direct exposure to light and electrical currents. The colloidal-silver solutions were tested against cultures of *Escherichia coli, Staphylococcus aureus, Staphylococcus epidermidis,* and *Bacillus subtillis* using antibacterial-activity testing (ABAT) and Kirby Bauer disc diffusion.

For ABAT, six wells were created using a sterile cork borer punching holes into the agar equidistant from each other. Each bacterial inoculum was swabbed over the agar surface. One drop each of the concentrations of colloidal silver (10 ppm, 20 ppm, 30 ppm), ophthalmic topical antibiotics

Table 2. **Antibacterial-activity testing.**

	Colloidal Silver			Antibiotics			
Organism	10 ppm	20 ppm	30 ppm	Tobramycin	Lomefloxacin	Moxifloxacin	Ampicillin
S. epidermidis	0	0	0	27 mm	31 mm	37 mm	20 mm
S. aureus	0	0	0	24 mm	28 mm	33 mm	19 mm
B. subtillis	0	0	0	29 mm	34 mm	36 mm	12 mm
E. coli	0	0	0	25 mm	27 mm	32 mm	18 mm

Table 3. **Kirby-Bauer disc-diffusion test.**

	Colloidal Silver			Antibiotics			
Organism	10 ppm	20 ppm	30 ppm	Tobramycin	Lomefloxacin	Moxifloxacin	Ampicillin
S. epidermidis	0	0	12 mm	22 mm	28 mm	32 mm	17 mm
S. aureus	0	0	22 mm	20 mm	23 mm	28 mm	16 mm
B. subtillis	0	0	22 mm	23 mm	25 mm	28 mm	10 mm
E. coli	0	0	0	24 mm	27 mm	32 mm	15 mm

tobramycin (Tobrex, Alcon Laboratories, Fort Worth, TX, USA), lomefloxacin (Okacin, CIBA Vision Ophthalmics, Basel, Switzerland), moxifloxacin (Vigamox, Alcon Laboratories, Fort Worth, TX, USA), and ampicillin were subsequently applied onto the agar well. Ampicillin was chosen as the control antibiotic due to the susceptibility of the test organisms to it.

For Kirby Bauer disc diffusion, sensitivity discs soaked with each antimicrobial, were placed equidistantly on the agar plate, which was inoculated with the test organism. Different plates with different test organisms were incubated for 24 hours at 35° Celsius. Drug sensitivity was subsequently assessed by measuring the area of clearing (in millimeters) around the antimicrobial tested or the zone of inhibition (Table 1), and the measurements compared with those of ampicillin to assess the resistance or susceptibility to the drug.

RESULTS

No inhibitory activity was noted for the 10-, 20-, and 30-ppm colloidal-silver preparations against *S. aureus, S. epidermidis, B. subtilis, and E. coli* on ABAT. Strong inhibitory activity was seen for tobramycin, lomefloxacin, and moxifloxacin while complete inhibitory activity was noted for ampicillin against the test organisms (Table 2).

Bacterial sensitivity to 30-ppm colloidal-silver preparation was demonstrated on Kirby Bauer disc-diffusion method (Table 3). The zone of inhibition of the 30-ppm preparation against *S. epidermidis* was noticeably smaller than that of tobramycin, lomefloxacin, moxifloxacin, and ampicillin. The zone of inhibition of the 30-ppm preparation against *S. aureus* was greater than that of tobramycin and ampicillin, but smaller than that of lomefloxacin and moxifloxacin. The zone of inhibition of the 30-ppm preparation against *B. subtilis* was smaller than that of tobramycin, lomefloxacin, and moxifloxacin, but greater than that of ampicillin. The 10-, 20-, and 30-ppm preparations of colloidal silver yielded no zones of inhibition against *E. coli*. The test antibiotics tobramycin, lomefloxacin, moxifloxacin, and ampicillin showed significant inhibition against *E. coli*.

DISCUSSION

Colloidal silver at a concentration of 30 ppm demonstrated significant inhibitory activity against *S. epidermidis, S. aureus,* and *B. subtilis* on the Kirby Bauer disc-diffusion method. This supports findings in previous studies that silver effectively inhibits the growth of these organisms, making colloidal silver an effective antimicrobial.

ABAT, however, yielded negative results which may be due to conditions and agents that affect the stability of colloidal silver. As recommended by the manufacturer, colloidal silver should be stored in a capped, amber-colored glass bottle to prevent direct contact with light. Contact with plastic also triggers an ionic reaction, causing particles of silver to start binding to each other instead of being dispersed in the aqueous medium. This clumping together of the silver particles produces an inferior-quality colloidal-silver solution as evidenced by a change in its color from light yellow to brownish. At this condition, the therapeutic action of colloidal silver is compromised.

Clinical observation suggests that our laboratory technique may have contributed to the negative results in ABAT. In the Kirby Bauer disc-diffusion test, the solution was absorbed by the sensitivity disc, thereby prolonging the action of colloidal silver over the agar plate by extending its evaporation time in contrast to ABAT, where the solution was dropped in a well on the agar plate. Future studies should, therefore, address the factors affecting the stability of colloidal silver.

In summary, this study demonstrated that the conflicting results regarding the antimicrobial activity of colloidal silver may be due to differences in study design and factors affecting the stability of the colloidal-silver solution.

References

1. Wadhera A, Fung M. Systemic argyria associated with ingestion of colloidal silver. *Dermatol Online J* 2005; 11: 12-20.
2. Dean W, Mitchell M, Lugo VW, South J. Reduction of viral load in AIDS patients with intravenous mild silver protein. *Clin Pract Alt Med* 2001; 2: 48-53.
3. Brandt D, Park B, Hoang M, Jacobe HT. Argyria secondary to ingestion of homemade silver solution. *J Acad Dermatol* 2005; 53: S105-S107.
4. Percival SL, Bowler PG, Russell D. Bacterial resistance to silver in wound care. *J Hosp Infect* 2005; 60: 1-7.
5. Lansdown AB, Sampson B, Laupattarakasem P, Vuttivirojana A. Silver aids healing in the sterile skin wound. *Br J Dermatol* 1997; 137: 728-735.
6. Katzung BG, et al. Basic in Clinical Pharmacology 6th edition: Disinfectants and Antiseptics. 1995; Chapter 51, p749.
7. Walker M, Cochrane CA, Bowler PG, et al. Silver deposition and tissue staining associated with wound dressings containing silver. *Ostomy Wound Manage* 2006; 52: 42-50.
8. Yamanaka M, Hara K, Kudo J. Applied Environmental Microbiology: 2005 Nov; Bactericidal actions of a Silver Ion solution on Escherichia Coli, studied by energy-filtering Transmission Electron Microscopy and Proteomic Analysis. 71(11): p7589-93.
9. Van Hasselt P, Gashe BA, Ahmad J. Colloidal silver as an antimicrobial: fact or fiction. *J Wound Care* 2004; 13: 154-155.

Acknowledgment

1. The authors thank Vicente O. Santos Jr., MD, medical director of Fatima Medical Center, for his invaluable support; and Joy Delfin, RMT, of Our Lady of Fatima University, for her assistance in performing the laboratory tests.