

Medical uses of silver

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The **medical uses of silver** include the use of silver in wound dressings, creams, and as an antibiotic coating on medical devices. While wound dressings containing silver sulfadiazine or silver nanomaterials may be used on external infections,^{[1][2][3]} there is little evidence to support such use.^[4] There is tentative evidence that silver coatings on endotracheal breathing tubes may reduce the incidence of ventilator-associated pneumonia.^[5] The silver ion (Ag⁺) is bioactive and in sufficient concentration readily kills bacteria *in vitro*.

Colloidal silver is not recognized as safe or effective by the FDA.^[6] Silver generally has low toxicity and minimal risk is expected for use in approved medical applications.^[7] Silver and silver nanoparticles are used as an antimicrobial in a variety of industrial, healthcare and domestic applications.^[8]

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Intervention

Contents

- 1 Medical uses
 - 1.1 Antibacterial cream
 - 1.2 Dressings
 - 1.3 Endotracheal tubes
 - 1.4 Catheters
 - 1.5 X-ray film
 - 1.6 Other uses
- 2 Adverse effects
- 3 Water purification
- 4 Mechanism of action
- 5 Alternative medicine
- 6 History
- 7 Cost
- 8 See also
- 9 References
- 10 External links

Medical uses

Antibacterial cream

A 2012 systematic review reported that topical silver showed significantly worse healing time compared to controls and showed no evidence of effectiveness in preventing wound infection.^[9] A 2010 Cochrane systematic review concluded: "There is insufficient evidence to establish whether silver-containing dressings or topical agents promote wound healing or prevent wound infection".^[4]

The US Food and Drug Administration has approved a number of topical preparations of silver sulfadiazine for treatment of second- and third-degree burns.^[10]

Dressings

A 2012 systematic review found that silver-containing dressings were no better than non-silver-containing dressings in treating burns.^[9] A 2012 Cochrane review found that silver-containing hydrocolloid dressings were no better than standard alginate dressings in treating diabetic foot ulcers.^[11] A 2010 Cochrane review found insufficient evidence to determine if dressings containing silver increase or decrease infection or affect healing rates.^[12] Another 2010 review found some evidence that silver-impregnated dressings improve the short-term healing of wounds and ulcers.^[13] The lead author of this paper is a speaker for one of the manufacturers of one of the silver dressings under study.^[13] A 2009 systematic review found that silver dressings improve both wound healing and quality of life when managing chronic non-healing wounds.^[14] Another 2009 review concluded that the evidence for silver-containing foam in chronic infected wounds is not clear, but found that silver-containing foam resulted in a greater reduction in wound size and more effective control of leakage and odor than non-silver dressings.^[15] A Cochrane review from 2008 found that, despite some potentially positive findings, most of the trials had methodological shortcomings and thus are of little use.^[16] The review also raised concerns about delays in time to wound healing and an increased number of dressing applications when silver sulfadiazine (SSD) is used for the full duration of the treatment.^[16] Another 2008 systematic review concluded that the evidence shows an overall positive effect of silver-releasing dressings in the management of infected chronic wounds, but expressed concern that the quality of the underlying trials was limited and potentially biased.^[17]

A number of wound dressings containing silver as an anti-bacterial have been cleared by the U.S. Food and Drug Administration (FDA).^{[18][19][20][21]}

Endotracheal tubes

Limited evidence suggests that endotracheal breathing tubes coated with silver may reduce the incidence of ventilator associated pneumonia (VAP) and delay its onset, although no benefit is seen in the duration of intubation, the duration of stay in intensive care or the mortality rate.^{[5][22][23]} Concerns have been raised surrounding the unblinded nature of some of the studies.^[5] It is unknown if they are cost effective,^[24] and more high quality scientific trials are needed.^[23]

The U.S. Food and Drug Administration in 2007 cleared an endotracheal tube with a fine coat of silver to reduce the risk of ventilator-associated pneumonia.^[25]

Catheters

Evidence does not support an important reduction in the risk of urinary tract infections when silver-alloy catheters are used.^[26] These catheters are associated with greater cost than other catheters.^[26]

Chlorhexidine-silver-sulfadiazine used in central venous catheters reduces the rate of catheter-related bloodstream infections.^[27]

X-ray film

Silver-halide imaging plates used with X-ray imaging were the standard before digital techniques arrived. Silver remains popular for its accuracy, and cost effectiveness, particularly in developing countries, where digital X-ray technology is usually not available.^[28]

Other uses

Silver compounds have been used in external preparations as antiseptics, including both silver nitrate and silver proteinate, which can be used in dilute solution as eyedrops to prevent conjunctivitis in newborn babies. Silver nitrate is also sometimes used in dermatology in solid stick form as a caustic ("lunar caustic") to treat certain skin conditions, such as corns and warts.^[29] Silver is also used in bone prostheses, reconstructive orthopedic surgery and cardiac devices.^{[7]:17} Silver diamine fluoride appears to be an effective intervention to reduce dental caries (tooth decay).^{[30][31]} Silver acetate has been used as a potential aid to help stop smoking; a review of the literature in 2012, however, found no effect of silver acetate on smoking cessation at a six-month endpoint and if there is an effect it would be small.^[32]

Adverse effects

Though toxicity of silver is low, the human body has no biological use for silver and when inhaled, ingested, injected, or applied topically, silver will accumulate irreversibly in the body, particularly in the skin, and chronic use combined with exposure to sunlight can result in a disfiguring condition known as argyria in which the skin becomes blue or blue-gray.^{[7][33]:121} Localized argyria can occur as a result of topical use of silver-containing creams and solutions, while the ingestion, inhalation, or injection can result in generalized argyria.^{[34][35]} Preliminary reports of treatment with laser therapy have been reported. These laser treatments are painful and general anesthesia is required.^{[36][37]} A similar laser treatment has been used to clear silver particles from the eye, a condition related to argyria called argyrosis.^[38] The Agency for Toxic Substances and Disease Registry (ATSDR) describes argyria as a "cosmetic problem".^[39]

While argyria is usually limited to skin discoloration, there are isolated reports of more serious neurologic, renal, or hepatic complications caused by ingesting colloidal silver.^{[34][40]}

One of the more publicized incidents of argyria came in 2008, when a man named Paul Karason, whose skin turned blue from using colloidal silver for over 10 years to treat dermatitis, appeared on NBC's "Today" show. Karason died in 2013 at the age of 62.^[41]

Colloidal silver may interact with some prescription medications, reducing the absorption of some antibiotics and thyroxine among others.^[42]

Some people are allergic to silver, and the use of treatments and medical devices containing silver is contraindicated for such people.^[7] Although medical devices containing silver are widely used in hospitals, no thorough testing and standardization of these products has yet been undertaken.^[43]

Water purification

Electrolytically-dissolved silver has been used as a water disinfecting agent, for example, the drinking water supplies of the Russian Mir orbital station and the International Space Station.^[44] Many modern hospitals filter hot water through copper-silver filters to defeat MRSA and legionella infections.^{[45]:29} The World Health Organization includes silver in a colloidal state produced by electrolysis of silver electrodes in water, and colloidal silver in water filters as two of a number of water disinfection methods specified to provide safe drinking water in developing countries.^[46] Along these lines, a ceramic filtration system coated with silver particles has been created by Ron Rivera of Potters for Peace and used in developing countries for water disinfection (in this application the silver inhibits microbial growth on the filter substrate, to prevent clogging, and does not directly disinfect the filtered water).^{[47][48][49]}

Mechanism of action

Silver and most silver compounds have an oligodynamic effect and are toxic for bacteria, algae, and fungi *in vitro*. Among the elements that have this effect, silver is the least toxic for humans. The antibacterial action of silver is dependent on the silver ion.^[7] The effectiveness of silver compounds as an antiseptic is based on the ability of the biologically active silver ion (Ag^+) to irreversibly damage key enzyme systems in the cell membranes of pathogens.^[7] The antibacterial action of silver has long been known to be enhanced by the presence of an electric field. Applying an electric current across silver electrodes enhances antibiotic action at the anode, likely due to the release of silver into the bacterial culture.^[50] The antibacterial action of electrodes coated with silver nanostructures is greatly improved in the presence of an electric field.^[51]

Silver, used as a topical antiseptic, is incorporated by bacteria it kills. Thus dead bacteria may be the source of silver which may kill additional bacteria.^[52]

Alternative medicine

Colloidal silver (a colloid consisting of silver particles suspended in liquid) and formulations containing silver salts were used by physicians in the early 20th century, but their use was largely discontinued in the 1940s following the development of safer and effective modern antibiotics.^{[33][55]} Since the 1990s, colloidal silver has again been marketed as an alternative medicine, often with extensive "cure-all" claims. Colloidal silver products remain available in many countries as dietary supplements and homeopathic remedies, although they are not effective in treating any known condition and carry the risk of both permanent cosmetic side effects such as argyria and more serious ones such as allergic reactions, as well as interactions with prescription medications.^{[29][56]}

Since about 1990, there has been a resurgence of the promotion of colloidal silver as a dietary supplement, or homeopathic remedy,^[29] marketed with claims of it being an essential mineral supplement, or that it can prevent or treat numerous diseases, such as cancer, diabetes, HIV/AIDS, herpes,^[33] and tuberculosis.^{[29][57][58]} No medical evidence supports the effectiveness of colloidal silver for any of these claimed indications.^{[29][56][59]} Silver is not an essential mineral in humans; there is no dietary requirement for silver, and hence, no such thing as a silver "deficiency".^[29] There is no evidence that colloidal silver treats or prevents any medical condition, and it can cause serious and potentially irreversible side effects such as argyria.^[29] In August 1999, the U.S. FDA banned colloidal silver sellers from claiming any therapeutic or preventive value for the product,^[56] although silver-containing products continue to be promoted as dietary supplements in the U.S. under the looser regulatory standards applied to supplements.^[56] The FDA has issued numerous Warning Letters to Internet sites that have continued to promote colloidal silver as an antibiotic or for other medical purposes.^{[60][61][62]} Despite the efforts of the FDA, silver products remain widely available on the market today. A review of websites promoting nasal sprays containing colloidal silver suggested that information about silver-containing nasal sprays on the internet is misleading and inaccurate.^[63]

Colloidal silver



A bottle of colloidal silver

Alternative therapy

NCCIH Classification	Whole medical systems
School	Homeopathy
Risks	Argyria, decreased drug absorption, ^[29] increased antimicrobial resistance ^[53]
Benefits	Placebo
Legality	Not to be sold for consumption or for disinfection in Sweden. ^{[53][54]} Not to treat or prevent cancer (UK, Sweden, etc.)

In 2002, the Australian Therapeutic Goods Administration (TGA) found there were no legitimate medical uses for colloidal silver and no evidence to support its marketing claims.^[64] The U.S. National Center for Complementary and Integrative Health (NCCIH) warns that marketing claims about colloidal silver are scientifically unsupported, that the silver content of marketed supplements varies widely, and that colloidal silver products can have serious side effects such as argyria.^[29] In 2009, the USFDA issued a "Consumer Advisory" warning about the potential adverse effects of colloidal silver, and said that "...there are no legally marketed prescription or over-the-counter (OTC) drugs containing silver that are taken by mouth."^[65] Quackwatch states that colloidal silver dietary supplements have not been found safe or effective for the treatment of any condition.^[66] *Consumer Reports* lists colloidal silver as a "supplement to avoid", describing it as "likely unsafe".^[67] The *Los Angeles Times* stated that "colloidal silver as a cure-all is a fraud with a long history, with quacks claiming it could cure cancer, AIDS, tuberculosis, diabetes and numerous other diseases."^[68]

It may be illegal to market as preventing or treating cancer, and in some jurisdictions illegal to sell colloidal silver for consumption.^[53] In 2015 a British man was prosecuted and found guilty under the Cancer Act 1939 for selling colloidal silver with claims it could treat cancer.^[69]

History

Hippocrates in his writings discussed the use of silver in wound care.^[70] At the beginning of the twentieth century surgeons routinely used silver sutures to reduce the risk of infection.^{[70][71]} In the early 20th century, physicians used silver-containing eyedrops to treat ophthalmic problems,^[72] for various infections,^{[73][74]} and sometimes internally for diseases such as tropical sprue, epilepsy, gonorrhea, and the common cold.^{[29][55][75]} During World War I, soldiers used silver leaf to treat infected wounds.^{[70][76]}

Prior to the introduction of modern antibiotics, colloidal silver was used as a germicide and disinfectant.^[77] With the development of modern antibiotics in the 1940s, the use of silver as an antimicrobial agent diminished.^[43] Silver sulfadiazine (SSD) is a compound containing silver and the antibiotic sodium sulfadiazine, which was developed in 1968.

Cost

The National Health Services in the UK spent about 25 million pounds on silver-containing dressings in 2006. Silver-containing dressings represent about 14% of the total dressings used and about 25% of the overall wound dressing costs.^[78]

Concerns have been expressed about the potential environmental cost of manufactured silver nanomaterials in consumer applications being released into the environment, for example that they may pose a threat to benign soil organisms.^[79]

See also

- List of ineffective cancer treatments
- Colloidal gold
- Stan Jones (politician)

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- "Integrative Medicine: Colloidal Silver". Memorial Sloan-Kettering Cancer Center.

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