

# History of the Medical Use of Silver\*

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## Abstract

**Background:** Silver has been used extensively throughout recorded history for a variety of medical purposes.

**Methods:** A review of the literature in English was undertaken, primarily using PUBMED, to identify the medical uses of silver before the clinical introduction of antibiotics in the 1940s.

**Results:** Silver has been used for at least six millennia to prevent microbial infections. It has been effective against almost all organisms tested and has been used to treat numerous infections and noninfectious conditions, sometimes with striking success. Silver also has played an important role in the development of radiology and in improving wound healing.

**Conclusion:** Silver was the most important antimicrobial agent available before the introduction of antibiotics.

**M**ETALLIC SILVER was known to the Caldeans as early as 4,000 B.C.E., and it was the third metal known to be used by the Ancients, after gold and copper [1]. Over these millennia, silver has been used for numerous medical conditions, mostly empirically before the realization that microbes were the agents of infection. The metal was used in many configurations, including vessels or containers for liquid, coins, shavings, foils, sutures, solutions (e.g., nitrate, oxide, bromide, chloride, and iodide), colloids providing fine particles, and electric colloids (introduced in 1924, which provide even smaller particles of 0.1  $\mu\text{m}$  to 0.001  $\mu\text{m}$  in diameter). Electric colloids of silver became the mainstay of antimicrobial therapy in the first part of the 20<sup>th</sup> Century until the introduction of antibiotics in the early 1940s. Complexes of silver and protein known as mild silver proteins also were employed. These formulations were delivered topically (by solution, ointment, or direct application of colloids or foils), orally, and by injection. By 1940, at least 50 silver products were marketed in the United States.

## Medical Uses of Silver B.C.E.

Herodotus, the Father of History, accounts that no Persian king, including Cirrus, would drink water that was not transported in silver containers, which kept the water fresh for years. This was particularly important in military conflicts, where fresh water from natural sources was not readily available [2]. The ancient Phoenicians, Greeks, Romans, Egyptians, and others also were recorded to have used silver in one form

or another to preserve food and water, and this was practiced through World War II.

The application of silver plates to achieve better wound healing was used by the Macedonians, perhaps the first attempt to prevent or treat surgical infections. Hippocrates used silver preparations for the treatment of ulcers and to promote wound healing. It is likely that silver nitrate also was used medically because it was mentioned in a pharmacopeia published in Rome in 69 B.C.E. [1].

## Medical Uses C.E. to 1800

The first clear record of silver nitrate being used as a medical agent was reported by Gabor in 702–705, and Avicenna used silver filings as a blood purifier in 980 A.D. and also to prevent palpitations of the heart and to treat offensive breath. Somewhat later (1520), Paracelsus used silver internally and also applied silver nitrate as a caustic for the treatment of wounds, a practice that continues today. In 1614, Angelo Sala gave silver nitrate internally as a counterirritant, as a purgative, and for the treatment of brain infections. During this same time, the Alchemists, who connected the seven planets to the seven days of the week as well as to parts of the body, connected silver to the moon and the brain, giving birth to terms such as “the silver moon” and “lunatic.” Silver later came into vogue for the treatment of epilepsy when an epileptic stopped having seizures after he swallowed a large silver coin used to prevent him from biting his tongue [1].

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FIG. 1. J. Marion Sims. Reproduced from Sims JM. *The Story of My Life*. New York. D. Appleton & Co. 1888.

During the early pioneer days on the North American continent, when there was no refrigeration and water needed to be transported long distances, it was common practice to drop silver coins into the transport vessel to preserve water. This practice also was used to preserve milk and prevent spoilage, without knowledge that it was the prevention of bacterial growth that caused the effect. During the late 1700s, Anton van Leeuwenhoek invented the microscope, leading to the examination of almost all substances and tissues. Animalcules, small viable particles most now known to be bacteria, were discovered, but their presence in the mouth and tissues of healthy individuals convinced some that animalcules were not associated with disease. Others soon began to recognize that they might be agents of infection.

Privileged families used silver eating utensils and often developed a bluish-gray discoloration of the skin, thus becoming known as “blue bloods.” Privileged people also often avoided sunlight so that the presence of the bluish discoloration, argyria,

might become even more prominent. The prevalence of argyria prior to 1800 has not been documented, but it was reported to be associated with a reduced mortality rate during epidemics of plague and other infectious diseases.

#### Medical Uses 1800–1900

By 1800, there was wide acceptance that wine, water, milk, and vinegar stayed pure for longer periods of time when stored in silver vessels. Silver nitrate also was used successfully to treat skin ulcers, compound fractures, and suppurating wounds, well before the time of Lister.

One of the seminal contributions to the medical uses of silver was by Doctor J. Marion Sims in 1852 [3] (Fig. 1). Sims became engrossed with the problem of vesico-vaginal fistulas, which were created at the time of delivery, especially in slave woman, who often had rickets and deformed pelvises. These young, otherwise healthy women became social

outcasts because of their continued incontinence, uncleanness, and stench. This was only shortly after Semmelweis was able to decrease puerperal sepsis by improved hygiene through hand washing, but before Pasteur showed that bacteria caused disease and well before Lister's successful use of antiseptics to prevent surgical site infections in 1867. Sims went so far as to keep these slave women in a small hospital near his home so he could be more attentive to their care. He tried many times to repair the fistulas surgically using standard sutures, such as silk, but these attempts all failed. Convinced that silver had healing properties, he had his silversmith produce fine silver wires that he then used as sutures to close the fistulas. This was highly successful, the first success being in a slave woman named Anarcha, who had undergone 12 previous operations using silk for closure. Sims became widely recognized as the first American surgeon to achieve international renown, traveling throughout Europe to demonstrate his successful techniques. He also used silver catheters for urinary diversion until the repairs had healed. At one time, Sims declared boldly that the use of silver sutures was one of the major contributions to surgery in the 1800s. Other sutures were introduced that were coated with silver, but the success of these was not well documented.

Another seminal contribution was made in the 1880s by Doctor Carl Siegmund Franz Crede, a German obstetrician, who pioneered the use of silver nitrate eye drops to prevent ophthalmia neonatorum (gonorrheal ophthalmia) in newborn infants [4]. He first used a 2% solution, but this was reduced subsequently to a 1% solution because of the irritation the higher concentration caused. This was a highly effective therapy, reducing the incidence of ophthalmia neonatorum from 7.8% to 0.13% in 13 years. Because of the success of this method, the employment of silver nitrate eye drops in newborn infants was widely accepted throughout the world, and in numerous countries, this therapy was mandated by law and persisted until after the introduction of effective antibiotics.

B.C. Crede, a surgeon, is credited with being the first to employ colloidal silver for wound antisepsis in 1891, after observing Halsted applying silver foil to wounds to treat infections [1,2]. Topical application of silver salts became a common therapy. Crusius used silver nitrate for the treatment of burn injuries in the 1890s, well before its recent rediscovery. Vonnaegele realized that the antibacterial effects of silver were attributable primarily to the silver ion, and did systematic studies that led to the finding that silver was an effective antimicrobial agent for almost all unicellular organisms (at least 650 species), but frequently not against mold or parasites [5]. Silver also had another use in medicine during the 19<sup>th</sup> Century, in that Konrad Röntgen discovered in 1895 that X-rays activated silver halide crystals, making it possible to record radiographic images.

### Medical Uses 1900–1940

Halsted was one of the first American surgeons to advocate the use of silver foil for wound dressings, and silver sutures often were used in surgical incisions to prevent infections. The use of silver for ophthalmologic treatment was extended considerably. Roe [6] used a colloidal form of silver in the successful treatment of infected corneal ulcers, interstitial keratitis, blepharitis, and dacryocystitis. Colloidal silver also was reported to be effective treatment for puerperal sepsis, staphylococcal sep-

sis, tonsillitis, acute epididymitis, and other infectious diseases [7–9].

Between 1900 and 1940, tens of thousands of patients consumed colloidal silver, and several million doses of silver were given intravenously. Whereas such therapy generally is safe, it was shown that high doses of silver, when given parenterally, could cause convulsions or even death, and that oral administration of huge doses could cause gastrointestinal disturbances.

### Argyria

Argyria, the deposition of silver in normal skin and other tissues, came to be a known complication of silver therapy. Because of this and the increasing use of silver for medical therapy, the American Silver Producers Association recruited W.R. Hill and D.M. Pillsbury to examine the incidence and consequences of argyria [1]. They searched the world literature and were able to find 357 cases that had occurred by 1939. The earliest cases were recorded in the 1700s. It became apparent that silver compounds administered by any route except the unbroken skin could produce argyria when used for a sufficiently long period of time. However, chronic argyria appeared to cause no pathologic alterations of the affected organs and to have no important physiologic consequences. In clinical practice, the gastrointestinal tract probably was the most important site to absorb silver. Once in the body, silver can be deposited in the majority of tissues, nerve tissue and skeletal muscle excepted. Two hundred thirty-nine of the 357 cases of argyria occurred as the result of silver given for medical indications. The remainder was related primarily to industrial uses such as mining and refining. In only 16 of the 239 cases where silver was given for medical indications had it been used for less than one year, and most of the patients with argyria had taken silver for a much longer time, as long as 20 years. Silver nitrate was responsible for 49% of these cases. The total dose of silver needed to cause argyria with silver arsenamine was approximately 6 g, or 0.9 g of metallic silver. In one interesting case, the only contact with silver was when silver structures were used to repair a hernia.

### Recommended Uses of Silver by the 20<sup>th</sup> Century

Over time, the well-established indications for the effective use of silver were for water purification, wound dressings for the promotion of healing, the prevention and treatment of infection, dental hygiene (the prevention and correction of pyorrhea, gingivitis, and bad breath), eye conditions (primarily the prevention of ophthalmia neonatorum), and other infectious complications.

Less clear evidence of effectiveness (possibly effective) exists for use for epilepsy and central nervous system disorders, a variety of digestive disorders, as a tonic in old age or disability, and for the treatment of arthritis, hemorrhoids, dandruff, and warts. Silver also was recommended for a wide variety of other diseases where effectiveness was questionable. These included diabetes mellitus, obesity, colds, psoriasis, allergies, and many others.

### Conclusions

Historically, silver has been a major therapeutic agent in medicine, especially in infectious disease, including surgical infections. Its risk:benefit ratio is advantageous.

**Author Disclosure Statement**

No conflicting financial interests exist.

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