A Closer Look at Silver

A Clinical Information Tool (CIT) to help you choose the right silver wound dressing for your patient!
A Closer Look at Silver is a tool that brings together key evidence-based information related to silver in wound dressings. It is a general resource intended for educational purposes only. For more in-depth information, please refer the Further Reading and Resources list on page 12.

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Introduction

Silver-impregnated dressings are an anti-microbial technology that can assist the clinician in the management of wounds both at risk for infection and already infected.

Like any wound management technology, silver dressings can be both misunderstood and misused. This CIT is intended to assist you in understanding the role of silver in the management of bioburden in the wound. The first and second sections review the basic concepts of silver in wound dressings. This review will enable you to better evaluate the type of silver to use and how each type impacts the wound environment. This will allow you, the wound care clinician, to make the best silver dressing choice for your patients. The third and final section will provide you with a decision-making framework to ensure you have the right silver dressings available in your clinical setting.

A Long History

Historically, silver has been used for many purposes, including water purification and the prevention of food spoilage. Documentation as far back as 750 BCE indicates that silver was also used medicinally. Hippocrates, the father of modern medicine, noted in the 4th century BCE that silver had beneficial healing and anti-disease properties, but it was not until 1881 that the first scientific paper on silver in medicine was published. With ongoing research we now know that active, or ionic, compounds can be destructive to living organisms, acting as a biocidal agent in the wound and other environments.
SECTION 1:

Silver 101

How does modern silver technology work as a topical bioactive agent against harmful micro-organisms?

Silver (Ag) is an element that can be described in many different ways—which can sometimes lead to confusion by health-care professionals. Silver exists in several forms, such as silver nitrate, silver chloride, and silver oxysalts (See Table 1). Silver is also either ionic (it carries a positive electrical charge) or non-ionic (has no electrical charge). In order for silver to be biocidal—it can interact with cell tissues and reduce harmful micro-organisms in a wound—it must be in an ionic form. Ionic forms of silver are indicated by plus signs (+), meaning the form contains a positive charge. The higher the ionic state (the more plus signs) the greater the ability of the ionic silver to interfere or react with the normal function of a micro-organism’s cell. For example Ag$^{3+}$ is more likely to interfere or react with the normal function of a cell than is Ag$^{1+}$.

Table 1: Silver Compounds

<table>
<thead>
<tr>
<th>Type of Silver</th>
<th>Chemical Formula</th>
<th>Oxidation State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallic silver</td>
<td>Ag</td>
<td>Ag$^0$</td>
</tr>
<tr>
<td>Silver sulfadiazine</td>
<td>AgC$<em>{10}$H$</em>{9}$N$_4$O$_2$S</td>
<td>Ag$^{1+}$</td>
</tr>
<tr>
<td>Silver chloride</td>
<td>AgCl</td>
<td>Ag$^{1+}$</td>
</tr>
<tr>
<td>Silver sulfate</td>
<td>Ag$_2$SO$_4$</td>
<td>Ag$^{1+}$</td>
</tr>
<tr>
<td>Silver oxide</td>
<td>Ag$_2$O</td>
<td>Ag$^{1+}$</td>
</tr>
<tr>
<td>Silver oxysalts</td>
<td>Ag$<em>7$NO$</em>{11}$</td>
<td>Ag$^{1+}$, Ag$^{2+}$, Ag$^{3+}$</td>
</tr>
</tbody>
</table>
In the pre-antibiotic era, silver was one of the primary treatments for infection in wounds, but the use of silver diminished when antibiotics were discovered. Unfortunately, antibiotic resistance occurred almost immediately upon the discovery of penicillin and is evident for every class of antibiotics used today. The good news is that, because silver has multiple modes of action on organisms, resistance to silver is much less likely to arise. This low risk of resistance and the high level of efficacy of silver’s ability to aide in the management of a topical wound infection have now led to a more frequent use of silver in the clinical setting.

Bacteria and other micro-organisms such as fungi (including yeasts) are single-celled organisms that are highly sensitive to their surrounding environment and have rigid cell walls to protect their cellular membrane from environmental damage. Ionic silver, due to its positive charge, interacts with micro-organisms in the wound environment by pulling electrons (the basic building blocks involved in cellular interactions) away from the micro-organisms’ cellular components (see Fig. 1). When silver ions interact with the cell they can disrupt both the protein and DNA function of the micro-organism.

As a result, ionic silver is a useful, broad-spectrum biocidal agent effective against bacteria and fungi (biocidal...
agents interfere with these organisms’ ability to function and survive, while biostatic agents inhibit growth and cell reproduction). Different forms and concentrations of silver are used in wound care products, providing a range of bioactivity. While all ionic forms of silver can pull electrons from micro-organisms, the forms with higher reactivity (which includes forms with a higher oxidation state) are more likely to disrupt micro-organisms than forms of silver with lower reactivity. Also, because silver has multiple modes of action (see Table 2), the ultimate effect on micro-organisms is often greater than that of an antibiotic—which usually disrupts only a single metabolic pathway.

Table 2: Modes of Action for Ionic Silver

<table>
<thead>
<tr>
<th>Action</th>
<th>Impact on the Micro-organism</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Silver ions attack the micro-organism’s proteins outside and inside the cell wall and interfere with the normal functioning of the micro-organism.</td>
<td>Loss of cell function leads to micro-organism death.</td>
</tr>
<tr>
<td>2 Silver ions promote the formation of reactive oxygen species (ROS) inside the micro-organism, which causes significant damage to DNA and proteins.</td>
<td>This damage leads to micro-organism death.</td>
</tr>
<tr>
<td>3 Silver ions interfere with the DNA replication required for the micro-organism to reproduce.</td>
<td>The micro-organism’s reproduction is disrupted.</td>
</tr>
</tbody>
</table>
How do silver dressings differ from each other?

Current research has expanded our knowledge of how silver works to address infection and has provided significant improvements in the development of silver dressings in areas such as rate of silver release, patient comfort, reduction in silver staining and overall efficacy. Silver-impregnated wound dressings can be constructed or designed in a variety of ways to release silver ions at the wound/dressing interface. However, it is important to note that silver compounds and dressing designs vary from one wound care product to another, and each of the compounds has a different reactivity and oxidation state. Different concentrations of each silver compound within the dressing are required to effectively manage the bioburden of a wound. To increase the reactivity and oxidation state some silver-containing wound care products may contain metallic silver (Ag<sup>0</sup>) combined with singly ionic silver (Ag<sup>+</sup>), allowing for a faster biocidal activity.

Silver with higher oxidation states (Ag<sup>2+</sup>, Ag<sup>3+</sup>) has only recently been incorporated into wound care products. When silver compounds with higher reactivity and oxidation states are present in a dressing, it is possible for them to contain a lower silver content and still have an excellent biocidal effect. There are several significant benefits of a higher oxidation state/lower silver content combination silver dressing:

- Lower potential toxicity
- Gentler action due to a more neutral pH

ARGYRIA

Argyria is a grey or blue-grey, permanent discoloration of the skin and mucous membranes that can occur after prolonged contact or excessive intake of silver.

This is not a toxic condition, but it can be cosmetically disfiguring. Modern silver dressings have a low level of silver and are less likely to cause sufficient systemic absorption that might lead to argyria.
- Reduced risk of argyria
- Lower production costs – because silver is a precious metal

The challenge for you as a clinician is to determine which silver product to choose to support the desired outcomes for each of your patients. The table below provides an overview of some of the most common silver compounds available. It can help you distinguish between different silver products and determine how each functions to support informed decisions in choosing the more appropriate dressings for your patients.

**Table 3: Silver Dressing Characteristics**

<table>
<thead>
<tr>
<th>Silver Form in the Wound Dressing</th>
<th>Silver Concentration (mg/100 cm²)</th>
<th>Dressing Design</th>
<th>Biocidal Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallic silver and silver oxide</td>
<td>160</td>
<td>Synthetic: polyester, polyethylene, rayon</td>
<td>✓</td>
</tr>
<tr>
<td>Silver chloride</td>
<td>12</td>
<td>Carboxymethyl-cellulose</td>
<td>✓</td>
</tr>
<tr>
<td>Silver oxysalts</td>
<td>40</td>
<td>Synthetic: polyester, polypropylene</td>
<td>✓</td>
</tr>
<tr>
<td>Silver sulfate</td>
<td>120</td>
<td>Silicone foam</td>
<td>✓</td>
</tr>
<tr>
<td>Silver sodium hydrogen zirconium phosphate</td>
<td>210</td>
<td>Synthetic: nylon, lycra, polyester</td>
<td>✓</td>
</tr>
<tr>
<td>Metallic silver</td>
<td>440</td>
<td>Nylon-based</td>
<td>✓</td>
</tr>
</tbody>
</table>
When should you choose to use a silver dressing?

Following a best practice approach, a thorough wound assessment and consideration of patient risk factors, their health status and personal environment as well as the needs of the wound dictate whether a silver dressing is appropriate.

The next decision is to choose the most appropriate dressing to meet your patient’s needs. Specific considerations for choosing a silver dressing include:

**Prevention or minimization of the risk of a wound infection:**

Silver dressings can be used when there is a:

- high risk of infection (sometimes based on the location of the wound—such as sacral areas that will likely come into contact with micro-organisms)
- complicated wound (such as those with foreign bodies or delayed treatment)
- partial- or full-thickness burn
- wound that is not likely to heal because of patient-related factors (such as non-adherence to treatment protocols)
- wound in a patient who is immuno-compromised
Management of a wound infection:

Silver dressings provide an option for topical management of a local wound infection and can be used in conjunction with oral or IV antibiotics to treat a systemic infection. Note: Infected wounds may require additional therapy such as debridement of necrotic tissue that can support the growth of micro-organisms.

Table 4, below, outlines the conditions and risk factors that should guide you in preventing or managing an existing infection.

Once you have decided that a silver dressing is appropriate always be sure to read the detailed information on the product information sheet before making a decision about which particular dressing is most appropriate to meet the needs of your patient and the identified outcomes.

Table 4: Infection: Associated Conditions and Risk Factors

<table>
<thead>
<tr>
<th>Colonized at Risk</th>
<th>Shows no signs of infection but patient has health-related conditions that increase their risk for wound infection, such as diabetes or other immune disorders, diminished arterial flow or medications that may alter their resistance to infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localized Infection (Critically Colonized)</td>
<td>Includes any two of the following: stalled healing, friable and bright red granulation tissue, increasing or altered exudate, increased malodour, localized edema, increased pain</td>
</tr>
<tr>
<td>Spreading/ Systemic Infection</td>
<td>Includes any of the above plus one or more of the following: induration and erythema extending well beyond wound borders, wound breakdown and/or satellite areas of breakdown, lymphangitis, general malaise</td>
</tr>
</tbody>
</table>
**Important Definitions**

**Contamination**: bacteria do not increase in number or cause clinical problems  
**Colonization**: bacteria multiply, but wound tissues are not damaged  
**Localized Infection**: bacteria multiply, healing is disrupted and wound tissues are damaged  
**Spreading Infection**: bacteria may produce problems nearby or cause systemic illness  
**Systemic Infection**: sepsis, shock, multi-organ failure, death

*From Wound Infection in Clinical Practice*

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**Section 1 Summary . . .**

All silver dressings are not equally effective. This overview of how silver works, how it differs based on its design and when it is appropriate for use to support the prevention and management of infection can assist you in making effective care decisions for your patient.

Silver-containing dressings should be used in cases where clinical signs of infection are present or where a patient has been identified as being at substantial risk for infection. Silver wound dressings should be used in a timely and appropriate manner and be accurately and regularly reassessed.

And remember . . . a dressing alone, whether it contains silver or not, may not heal a wound. Systemic (internal) and environmental (external) factors and the local wound environment must be considered when developing an individualized plan for patient care.
Further Reading and Resources


Section 2:

Silver Dressing Selection

How do you choose among the different silver dressings available? The following are questions you need to ask and goals you need to achieve when considering which dressing should be selected for your patient’s wound management plan.

How often should I review the prevention and/or management plan?

A single dressing type may not be appropriate over the entire span of your management plan. Dressing choice should be reassessed at least every two weeks to determine effectiveness (unless there is a negative change in the wound’s or patient’s status, in which case a reassessment should be done immediately). The decision may be made to move to a different delivery system (such as foams or films), to a silver dressing of faster or slower activity, or to discontinue the use of silver altogether.

What is the risk of silver staining?

Most silver dressings have minimal or temporary staining. Silver sulfadiazine cream is a notable exception that may cause permanent staining and should be avoided on facial wounds.
Can the dressing size and shape be altered?
In some cases the dressing needs to be cut to fit an unusual shape or location on the patient’s body. When this is the case, a silver dressing that can be cut to shape is preferred over a dressing that cannot be customized.

What is the biocidal activity level of the dressing?
Using a silver dressing with the appropriate bioactivity level may reduce time to heal and prevent negative side effects. In patients at risk for infection silver dressings with slow biocidal activity may be appropriate to prevent wound infection. In cases of systemic or spreading infection, silver dressings with fast biocidal activity may be essential components in a life- or limb-saving intervention. These patients should also be managed systemically as well as topically as part of a comprehensive infection management plan.

How long will this silver dressing remain active?
Long-wear dressings can be left on the wound as long as indicated by the product information sheet and allowed to be in contact with the wound for the entire duration. Short-wear dressings may be used when daily or frequent dressing changes are required. Longer-wear dressings that do not need to be changed frequently may be more appropriate in some cases because they may reduce patient discomfort and disruption to healing in the wound bed. As well, dressings with longer wear-time can aid in reducing overall cost by
decreasing the number of dressings required and by reducing the number of nursing visits—both important considerations.

**What different types of silver delivery systems are available?**

Silver can be delivered through a variety of dressing categories (such as foams, hydrocolloids and alginates) to address a range of wound environments. For heavily exudating wounds, for example, foam or hydrofibre dressings containing silver are available to absorb excess exudate as well as to handle bioburden. Wounds with minimal exudate* may require a silver dressing with minimal absorbency, such as a film or thin contact dressing.

*Some silver dressings may require pre-moistening to deliver and activate the silver effectively.

**What is the overall cost of the silver dressing?**

Silver is a fluctuating commodity that can be expensive. Therefore, the silver content in a dressing is one consideration in the overall production and manufacturing cost that affects a dressing’s direct price. A dressing that contains a higher content of silver (required to be effective if the silver contained within it has a lower oxidation state) may potentially be more costly than a dressing with a lower silver content and a higher oxidation state. Silver dressings that contain lower

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**Quick Silver Fact**

- Silver may have anti-inflammatory properties, but the clinical relevance of this still needs to be determined.
contents of silver but have higher oxidation states may potentially offer more effective biocidal effects (the higher oxidation state ensures a higher “kill rate”) with lower production and manufacturing costs. Cost-effectiveness is not determined by direct cost alone, but should also consider ease of use, wear time, nursing visits required, and the dressing’s effectiveness at prevention or management of wound infection.

**How does the silver dressing impact patient comfort?**

For patients with extreme sensitivity in the wound area, a slow and low pH shift will prevent or minimize burning and stinging on initial application of a silver dressing. It is important to identify the pH factor of each dressing as the pH shift of the more effective dressings can be higher—sometimes leading to short-term stinging at the wound site upon dressing change. It is pertinent to ask what studies have been done to determine the pH of the dressing on the wound and how it affects the patient experience. Dressings that provide fast biocidal action can reduce bioburden quickly, and therefore may reduce infection-associated pain faster than dressings that reduce infection more slowly. As well, some silver dressings may be designed with special non-adherent surfaces and provide increased comfort with removal.
SECTION 3:

Obtaining silver dressings in your care setting

If you are interested in trying new silver dressings in your clinical setting, the steps below outline a possible pathway that considers the best interests of patients, clinical staff and institutional/agency priorities.

**Step 1:** Discuss with your purchasing group (or other appropriate department) the possibility of entering into a relationship with a vendor of a product not currently in inventory. In most healthcare settings both sampling and clinical evaluations need to go through a formal process—usually initiated through the purchasing department.

**Step 2:** Sample the product by trying it on several patients for at least two weeks to get a feel for how it works and its ease of use. Document your findings using a systematic method or protocol. You and your patients can determine if the product warrants further investigation. If positive results are not observed, determine if best practice is occurring with your patient’s care. If you still do not have the results you desire or expect, then consider that this may not be the best product for the wound. Provide feedback to other team members, the purchasing department and the industry representative so they
become aware of the impact the product has had on patient care and clinician workload.

**Step 3:** Formally evaluate the product clinically—in a single or multi-site exploration—by performing a structured evaluation of the product over a 4–6 week period with several patients. The feedback on a formal evaluation is more extensive than that for the product sampling procedure in Step 2 as it provides more extensive communication among the patient, clinician, purchasing department and distributor, along with providing more meaningful data.

**Step 4:** If you see positive results that have had a meaningful impact on patient care, formally request that the purchasing or stores department include the product in their inventory. Purchasing/stores will weigh the request against a range of considerations, including existing contractual obligations to other like products.

**Step 5:** Once purchasing agrees to stock the product, educate/in-service staff before product distribution in the clinical setting. In some situations the product vendor provides a representative to in-service. It is important that all staff on all shifts have the opportunity to attend and that the person providing the in-service/education is skilled in adult learning principles.
Final considerations

It is important that you remain current and knowledgeable about wound dressings. New evidence on many aspects of wound care is being published all the time, resulting in the development of new technologies. As a clinician, you can support the delivery of best possible care for your patients by making informed, patient-centered decisions, influencing your agency or institution in best practices and making recommendations to the department making purchasing decisions.