Agicoat Silver Dressing on Wounds

A short Overview on wound Management

By

Scientific Department of Emad Pharmaceutical Co.
**Wound management**

Dressings are part of a holistic wound management plan with personalized patient goals. One goal may be to facilitate faster wound healing by providing the optimal environment for healing to proceed. However, it is necessary to look at the whole patient, underlying disease processes and patient-centred concerns before looking at the wound itself.

**Barriers to wound healing**

Wound bed preparation extends the existing practice of using a holistic approach to evaluate and remove all barriers to healing, so that wound repair can progress normally. The overall goal of and management is to achieve a stable wound that has healthy granulation tissue and one that is characterised by a well-vascularized wound bed. This would involve the removal of factors that delay healing. (2) Various factors may delay or impede healing. Local factors occur directly within the wound, whereas systemic factors occur throughout occur throughout the body. (3)

<table>
<thead>
<tr>
<th>Local factors</th>
<th>Systemic factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>• Blood supply (tissue perfusion)</td>
<td>• Haemodynamic conditions (perfusion, hypovolemia, hypoxia, pain, etc)</td>
</tr>
<tr>
<td>• Tissue oxygen tension</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>Important</td>
</tr>
<tr>
<td>• Tissue</td>
<td>• Age</td>
</tr>
<tr>
<td>• Mechanical stress of the tissue</td>
<td>• Smoking</td>
</tr>
<tr>
<td>• Hypothermia</td>
<td>• Medication</td>
</tr>
<tr>
<td>• Pain</td>
<td>• Diseases</td>
</tr>
<tr>
<td>• Radiation</td>
<td>• Nutritional status</td>
</tr>
<tr>
<td>• Infection</td>
<td>• Anemia</td>
</tr>
<tr>
<td>• Surgical</td>
<td>• Alcoholism</td>
</tr>
<tr>
<td>• Suture technique and materials</td>
<td>• Radiation</td>
</tr>
<tr>
<td>• Others (vasculitis, immunological, etc)</td>
<td>• Others (immunological, etc)</td>
</tr>
</tbody>
</table>

**Patient assessment**

Wound healing is determined by the general health of the patient. The assessment of the patient as a whole is critical for the planning and evaluation of care and should include:

- Medical history
- Cause of tissue damage
- Medication/allergies
- Other diseases such as:
- Diabetes
- Vascular disease
- Immune compromise
- Inadequate nutrition
- Lifestyle/environment
  - Obesity
  - Tobacco/alcohol abuse
- Impaired mobility
- Inadequate social network, caregiver support
- Psychological problems

**Wound assessment**

Wound assessment is not an exact science, but requires the skills and assessment of trained professionals. The following need to be assessed and carefully recorded at each dressing change:

- Cause: determine etiology
- Local wound characteristics:
  - Location
  - Size (length, width, depth)
  - Wound bed (black, yellow, red, pink, undermind)
  - Exudate (copious, moderate, mild, none)
  - Wound edge (ceiitus and scale, maceration, erythema, oedema)
  - Odour (absent, present)
- Patient concerns: pain (persistent, temporary)
- Condition of surrounding skin (normal, oedema, warmth, erythema)
- Clinical signs of critical colonization/local infection and infection (please see below table)

Assessment of the wound is a prerequisite to the selection of an appropriate dressing. Silver-containing dressings are widely used to assist with management of infected wounds and those at risk of infection.

The ideal silver dressing must:

- Combine antimicrobial effect and capacity to absorb exudates (4).
- Deliver silver in a sustained therapeutic way (4)
- Be supported by clinical documentation in randomised controlled trials
- Be easy to use and comfortable for the patient (4)
- Be cost-effective (4)
Indications of when to use silver dressings:

<table>
<thead>
<tr>
<th>Contamination/Colonisation Likely signs</th>
<th>Critical colonization/local infection Likely signs</th>
<th>Infection Likely signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>No local pain</td>
<td>New or increased pain at wound site</td>
<td>Severe or increased pain at wound and surrounding tissue</td>
</tr>
<tr>
<td>No fever</td>
<td>No fever</td>
<td>Fever, systemic symptoms</td>
</tr>
<tr>
<td>Normal smell</td>
<td>May have odour</td>
<td>Foul or excessive odour</td>
</tr>
<tr>
<td>Healthy granulation</td>
<td>Abnormal/absent granulation</td>
<td>Abnormal granulation or necrotic tissue</td>
</tr>
<tr>
<td>Minimal exudate</td>
<td>Excessive or increases serous exudate</td>
<td>Excessive and purulent exudate</td>
</tr>
<tr>
<td>Normal wound margin</td>
<td>Possible tunneling or pocketing</td>
<td>Tunneling, pocketing, maceration, oedema, erythema, warmth</td>
</tr>
<tr>
<td>Healing wound *</td>
<td>Static wound</td>
<td>Increased wound size</td>
</tr>
</tbody>
</table>

*Select a wound dressing that provides moist wound healing. Topical antimicrobial (e.g., sustained silver release) dressing may be used if risk of infection is a concern. Always conduct a thorough assessment, as it will determine the treatment.

Topical antimicrobial (e.g., sustained silver release) dressings are appropriate. Always conduct a thorough assessment, as it will determine the treatment.

Systemic antibiotics are appropriate. Topical antimicrobial (e.g., sustained silver release) dressings may give added benefit together with systemic coverage. Always conduct a thorough assessment, as it will determine the treatment.

*A 20%–40% reduction of wound area in 2 to 4 weeks is likely to be a reliable predictive indicator of healing; the efficacy of this fact.

Has been demonstrated specifically for venous leg ulcers.(7)

**Agicoat silver wound dressing**

The Agicoat wound contact dressing is designed to be a multiday antimicrobial post surgical wound and burns wound dressing, and is designed to be placed in primary contact with the wounds. The Agicoat wound contact layer is a specially designed flexible knit polymeric fabric 100% coated with a layer of pure metallic silver. The woven textile is composed of medical grade nylon.

There are several dressing that contains silver in different form currently, However, such dressings have varied responses in clinical use due to technological differences in the nature of their silver content and release and in properties of the dressings themselves.(8)

Agicoat is third dressing after Silverlon® and Acticoat® using pure metallic silver on its surface as source of silver ion, the antimicrobial agent. Use of metallic silver has some advantage such as slow and control
release of ionic silver, resistant to solvent and wound exudates to other type like hydrocolloid and silver salt wound dressing. For every dressing the best evaluating index is studies performed on dressing in vitro and clinically. Agicoat had been passed several studies and established its effectiveness for varieties of wounds in complicated conditions. In future page you will see some of important studies on Agicoat.

Agicoat is manufactured by autocatalytic silver plating technique and the silver deposit on nylon fabric has grain bindery below micron and in nanometer range as show in picture.

References:

7: Till this section is partially modified from Gottrup, F. et al., Clinical wound Assessment, A poker Guide.
Agicoat

Clinical Trials and comparison studies
The effect of silver nylon wound dressing on micro flora and clinical outcome of acute facial wounds

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Abstract

Wound dressing are widely used in surgery for management of wounds. The factors of the wound healing response in vivo may be influenced by bacteria within the wound. While the application of inert or bioactive dressing material remains largely uninvestigated in wound healing on the face, where the optimization of wound healing and minimization of scarring has the most importance cosmetically. The randomized, controlled trial was performed on 46 patients with acute facial wounds. Following primary closure, patients were provided with either a normal-gauze dressing or a silver nylon dressing, the wounds were assessed clinically on 5, 28, 56th days and microbiologically prior to closure of the wound and then on day 5. Vancouver scar scales (VSS) is used for assessing the wound. Observers were blind and in depended. Wounds treated with the silver nylon dressing have lower VSS compare to normal dressing at day 28 and 56(p<0.001), also at day 5, 28 and 56 within groups there were statistically difference between the VSS the microorganisms count were obtained from both treatment groups before the closure of the wound and then on day 5. silver nylon dressing group had microbial count lower than normal dressing at 5th day(p<0.001).

Keywords: Bacterial Flora; Facial Wound; Silver nylon dressing; Wound Healing
**Introduction:**

Healing of most facial wounds progresses uneventfully (1). However, following traumatic or surgical injury, wounds do not heal by tissue regeneration but rather by scar formation (2) that represents a considerable clinical and psychological problem for the affected individual (3). Facial wounds, resulting by interpersonal violence, accident or sports injury are more common (4). The oral and maxillofacial surgery Department of Tehran university of medical Science in Shariati Hospital treats over over than 2000 patients each year with facial injury. Attempts have been made to modulate wound healing processes by variety of physical and biochemical treatments to minimize scarring.

Cataneous wound healing is a complex biological process involving the action of cytokines, resident and migratory cell types and the extra cellular matrix (ECM). The factors of wound healing may be influenced by bacterial contamination of wound and the applications of inert or bioactive dressing. Healing of facial wounds has most importance cosmetically (4). The bacterial micro flora of skin may potentate scarring by protease production, stimulation of inflammation and ECM deposition. Consequently, the role of bacteria in nonhealing skin wounds such as chronic leg ulcers has received considerable attention (5).

Use of topical antimicrobial agents is one of the approaches for minimizing the wound infection risk that could reduce the microbial contamination of wound and chance of infection (6). Dressing are used widely in surgery for management of wounds. As knowledge of the wound healing process has expanded, increasing arrays of products have been developed to treat the varying problem that occurs (7).

Silver has been used as antimicrobial agent for over a century with few side effects. Silver containing dressing have been reported to preventing infections as well as improving wound healing (8,12).

A new brand of silver nylon dressing named as agicoat and combined of thin layer of silver deposited on woven nylon textile, recently introduce to Iranian market. It inhibites the growth of Staphylococcus aureus, Staphylococcus epidermidis, Pseudomonas aeruginosa and Escherichia coli for seven days (13). The silver layer over the nylon fabric in agicoat deposited by autocatalytic silver palting method and consist of 99.9% pure metallic silver and 0.1% silver oxide. Silver ion release from the metallic layer when it exposed to moisture. Invitro tests have confirmed yhay the agicoat dressing can release antimicrobial silver over seven days. Sustained release of silver is not only important by reducing bacteria burden but also highly significants in terms of decreasing mechanical trauma. This kind of silver nylon dressing can be left in place for up to seven days, meaning that the wound does not have to manipulate during this period, which could cause trauma to the new epithelia growth and may spread bacteria into blood stream. The extended wear of this dressing means that the patient does not have to be removed or disturbed, which decreases pain and nursing time (12).

The most important reason why the normal dressing are so frequently used is the very low cost of the product; however, if we want to consider the total cost of the treatment, we also need to evaluate the cost of nursing care and cost of the outcomes. Gauze dressing need to change frequently (once or twice a day) and the cost of nursing care increase accordingly (14). Despite the potential of bacteria modulating scarring in acute wound healing; there is little information on either the micro flora of acute facial wounds or their contribution to clinical outcome (4). The aim of study is compare two wound care methods with respect to microbiological and healing assessment.
Methods

Test materials
Agicoat wound dressings with single layer silver coated woven nylon textile were obtained as 10 cm*10 cm and produced by emad pharmaceutical co. (Iran)

Steril woven normal-gauze dressing prepared as 10 cm *10 cm produced by Latif co, Iran.

Clinical procedures
The study design consisted of a randomized (block randomization method), controlled trials of 46 patients with acute facial wounds. Approval for this study was obtained from the local ethical committee. Standard demographic information was recorded on all patients (age, sex, etiology, location and length of wound). Patients with systemic and local disease or therapeutic regimes likely to were excluded from our study.

Study protocol: following microbial sampling of the wound surface with a swab, the wounds were all cleansed with 0/05% Chlorhexidine gluconate and closed with interrupted 5/0 nylon sutures.

Patients were randomly provided with either a normal gauze dressing (n=23) or silver nylon dressing agicoat. (n=23)

In the control group, the normal dressing was changed once a day for 5 days and in study group, silver nylon dressing were used for 5 days and moisture twice a day with distilled water then removed at fifth day. The wound of all patients was assessed on days 5, 28 and 56 following the injury.

Wound healing Assessment
Clinical outcome was assessed at 5, 28, 56 days following Injury. Scare were assessed by two Blinded examiners. Clinical assessment of wound healing was recorded by the Vancouver scar scale(vss).

Pigmentation, vascularity, pliability and height were assessed independently, with increasing scores being assigned to worse condition.

Pigmentation(normal color=0, Hypopigmentation=1, Hyperpigmentation=2), Vascularity(normal=0, pink=1, Red=2, Putple=3), pliability(normal=0, Supple=1, yielding=2, frame=3, Banding=4, contracture=5), Height(normal=0,<2mm=1,>2mm and< 5 mm=2,>5mm=3).

Each of four parameters is assigned numbers according to the previously mentioned characteristics.

Scores from all parameters are added together to attain a final VSS score.

Determination of the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of dressing.
Four Strains of microorganisms Staphylococcus aureus(ATCC 6538), Staphylococcus epidermidis (ATCC 2222), Escherichia coli(ATCC 3987) and Pseudomonos aeruginosa (ATCC 9027) were used as test organisms minimum inhibitory concentrations of the samples were determined using a tube dilution method. Descending surface areas(square centimeters) of individual dressings were put into sterile test tubes each containing 1 ml of soybean casein digest broth (SCDB).The tubes were inoculated with an overnight culture of the test strains to reach a 10^9 cfu/ml prior to incubation at 37 degree of centigrade for 24 hours.
The tubes containing the lowest amount of equivalent silver and lacking turbidity were assigned MICs. The minimal bactericidal concentrations (MBCs) of the dressings were determined by adding 50 micro liters of the non-turbid tubes onto soybean casein digest agar (SCDA) plates and further incubation of the plates at 37 degree of centigrade for 24 hours. The plates incubated with the lowest concentrations of silver and no sign of bacterial growth were assigned as MBCs.

**Wound contamination assessment**

Wounds were swabbed in aseptic manner prior to closure and after 5 days. Swabs were immersed in 0.5 ml sterile normal saline and then were cultured on soybean casein digest agar plate by surface culture method and were incubated for 48 hours. Visible colonies on plates were counted and reported as total count.
Results:
Mean age "27.78 V 28.09" and mean length of wound "2.06 cm V 1.69cm" were similar in the two study groups (p>0.05, table 1). Young patients (with age range 20-30) comprised the majority (78.3% and 65.2%) of patients in boths groups. Accidents were the most common reason of the wounds. The majority of the wounds (mean length 2.06cm and 1.69 cm) were located on the upper third of face in the control group and middle third of face in case group( table2), therefor there were no significant clinical diffrences between case and control patients.

Table 1 clinical features of the patients and wounds in inclouded the study groups.

<table>
<thead>
<tr>
<th>Clinical feature</th>
<th>Silver dressing</th>
<th>normal dressing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age</td>
<td>27.78(20-67)</td>
<td>28.09(17-56)</td>
</tr>
<tr>
<td>Sex(M : F)</td>
<td>15:8</td>
<td>15:8</td>
</tr>
<tr>
<td>Mean length</td>
<td>2.06</td>
<td>1.69</td>
</tr>
</tbody>
</table>

Table 2 Site distributon of injuries

<table>
<thead>
<tr>
<th></th>
<th>Silver dressing</th>
<th>normal dressing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper third</td>
<td>9(39.1%)</td>
<td>10(43.5%)</td>
</tr>
<tr>
<td>Middle third</td>
<td>10(43.5%)</td>
<td>5(21.7%)</td>
</tr>
<tr>
<td>Lower third</td>
<td>4(17.4%)</td>
<td>8(34.8%)</td>
</tr>
</tbody>
</table>

Clinical outcome: At day 5, wounds treated with the silver nylon dressing had VSS similar to wounds treated with a normal dressing (p>0.1). At day 28 and day 56, wounds treated with the silver nylon dressing and VSS lower than wounds treated with a day dressing and this different was statistically significant (p<0.001). Wilcoxon signed ranks test to compare VSS at 5, 28 and 56 days in silver dressing group showed that there was significant difference between VSS AT 5,28 (P<0.001), 28, 56(P<0.001) AND 5, 56(P=0.005). This test for the normal dressing showed that there was significant difference between VSS at 5, 28 days (p=0.011), 5,56 days (p<0.001)(Fig.1).
MICs and MBCs determination of Agicoat showed the dressing could act as bactericidal agent against common type of pathogenic microorganism (table 4). MICs and MBCs calculate as dressing surface in square centimeter.

Microbiological Analysis: Microbiological count is presented in table 3. There was no statistically difference between microbial count befor closure in the both groups, but ANOVA test of microbial count after 5 days showed statistically difference between the two groups (p<0.001) and this indicated that the microbial count have decreased by using silver nylon dressing.

Table 3 Microbial countamination of wounds

<table>
<thead>
<tr>
<th>P value</th>
<th>Normal dressing C.F.U X±SD</th>
<th>Silver dressing C.F.U X±SD</th>
<th>microbial sampling date</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.S</td>
<td>791.74±15.08</td>
<td>811.74±190.71</td>
<td>Befor closour</td>
</tr>
<tr>
<td>&lt;0.001</td>
<td>909.13±127.28</td>
<td>64.71±98.17</td>
<td>At 5 days</td>
</tr>
</tbody>
</table>

N.S= Not Sighnificant
C.F.U= Colony Forming Unit

Table 4 MICs and MBCs (cm²/ml) Agicoat wound dressing.

<table>
<thead>
<tr>
<th>S.aureus (MIC/MBC)</th>
<th>S.epidermidis (MIC/MBC)</th>
<th>E.coli (MIC/MBC)</th>
<th>P.aeruginosa (MIC/MBC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5/5</td>
<td>1/2.5</td>
<td>2.25/2.75</td>
<td>1/3.5</td>
</tr>
</tbody>
</table>
Discussion:
Silver dressing is a relatively new form of silver antimicrobial barrier dressing which helps avoid the problems of earlier devices. It has rapid and sustained antimicrobial activity, and because of this may reduce inflammation and promote healing(6). The results of this study have shown that silver nylon dressing significantly decreased microbial count on day 5. It is demonstrate that Acticoat™ dressing could inhibit the growth of Pseudomonas aeruginosa and Staphylococcus aurous for a minimum of nine day(17) as well as MICs and MBCs for four strain of microorganisms shows invitro antibacterial efficacy for this new brand of silver dressing, Agicoat. Also Holder and coworkers showed Acticoat™ reduce microbial contamination of wounds and has capacity to serve as an antimicrobial barrier dressing (15).

Silver rapidly kill microbes by numerous mechanisms, the efficacy of which depends on the amount silverlons present (12,8). In 1988 Tredget et al demonstrated the safety and efficacy of Acticoat™ in the prevention of infection in burn wounds by reducing bacterial burden, Anti-inflammatory effects of Acticoat™ is appeared and contributed to more rapid healing. Persistent inflammation leads to infiltration of neutrophils and elevated Matrix Metalloproteinases (MMPs). MMPS play a part in ther controlled degradatio of extracellular matrix; elevated activities of these enzymes may lead to excessive matrix destruction. Acticoat™ can suppress MMP-9 activity and reducing TNF-α levels in the wounds (19,20).

In our study;Agicoat dressing significantly improved wound healing (decrease VSS) on day 28 and 56. Findigs are in in keeping with previous studies of acute wound healing under silver dressing (9,12,15,21,23). But the another study has suggested that donor sites dressed with Acticoat™ had significantly wors scars at 1 and 2 month but this difference resolved by 3 month. There findings do not support the use of Acticoat™ as a skin graft donor site dressing (22). Morever, in our study there is significant difference between VSS on day 5,28,56 within groups, that indicate the marked improvement of acute cutaneous facial wounds, but in comparison between groups, VSS in Agicoat as silver nylon dressing was lower than normal dressing group that meaning more similarity of scar tissue to normal skin in silver nylon dressing group. It should be pointed out however,thi study related to medically screened fit and healthy patients.

A similar situation may not occur in patients with chronic wounds at other sites who are after diabetes and whose wounds may be colonized with a bacterial microflora different to that observed in acute wounds. The present study has shown the short term clinical benefits of silver nylon dressing in the management of acute wounds. Due to frequency of acute facial wound and relatively homogenous pattern of patients and injuries the clinical model described here is particularly useful. This study has shown the potential value of facial wounds as a human model for studying . Acute wound healing responses, In which the effects of any anti-scaring therapy could be assessed. It should also be considered that the nurses and medical doctors traditionally use gauze in treatment of wounds and great effort will be needed to change this habit.

Acknowledgment
With special thanks to Emad pharmaceuticals for providing us free of change, Agicoat as Silver Nylon Dressing.
References:
1. Key SJ, Thomas DW, Shepherd JP. The management of soft tissue facial wounds. Br j oral maxillofac surg 1995;33:76-85
Nanocrystalline Silver Dressing Versus Silver Sulfadiazine: A Clinical Study of burn wounds

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bHarvard-MIT division of health science & Technology

Abstract
In this study we try to compare two types of burn wound treatment methods: new brand of nanocrystalline silver dressing "Agicoat" and silver sulfadiazine. Both therapy are effective for burn wounds but there are some advantage for silver dressing in literature. Our study shows again some advantage for using silver dressing in burn patient like as reduction of hospitalization period, lower use of pain killers, less wound infection or contamination and finally lower total cost for caring system. These finding encourage the health care system for using new emerging technology such as new wound dressing technologies.

Keywords: Burn wounds, Silver, Dressing, Sulfadiazine.
Introduction:

Burn wounds are great place for bacterial infection because of dead tissues, physiologic temperature and lack of immune system and supply. Infection is the most important reason of death after burn injuries(1). Such wounds are hard to prevent infection via systemic antibiotic and use of local antibiotic to lower the infection risk will be needed. Silver sulfadiazine 1% cream is one of old therapeutics is used in the field for long time(2). However studies had been found that it increase the healing times and therefore no long term use is recommended (3). But recently by introducing of new wound dressing technologies; the clinical protocol for burn wounds have been changed. One of emerging technology is dressing contains silver metal nanocrystals. These kind of dressing slowly release the silver ion by dissolving the metal crystals and producing the antimicrobial via local increase of silver ion in wound environment(4). However using of such dressing in burn wounds is not new for some brands such as acticoat but in this study we try to compare a new silver dressing entering to the Iranian and international market "agicoat" with traditional protocol like silver sulfadiazine cream in managing of burn wounds. The most important phenomenon which investigate in this study were: total hospitalization cost, infection control, pain reduction in both therapies.

Materials & methods:

a. Sampling volume and method: cases number was calculated according below equation and it shows it had been needed at least 34 cases in each group of study, control and experiment.

\[
\frac{(t_1, t_2)^2 \cdot (2 \cdot s^2)}{d^2}
\]

\( n \)

\( Z_1 \) is confidence level, \( Z_2 \) is critical standard score, \( S \) is derivative of standard deviation and \( d \) is minimum difference of two group average and it is equal to 0.65 going to the statistic calculation is out of paper interest.

b. All cases were selected randomly and placed in two groups, 35 patient as experiment using silver dressing and 34 patients as control using silver sulfadiazine as therapy. Selection of cases filtered by age, sex, burn type, burn percentage and special cases such as diabetic patients, burn person with coronary, heart and renal disease, chemical burns, electrical burns, trauma and ages less than 5 and more than 60 did not introduce to the study. All Results were analyzed by statistics methods such as cohort and fisher methods.

c. Methodology: for all incoming patient to the program were filled a demography form and after release all cost such as antibiotic, nursing, pain killer medicine, dressing and other costs were calculated. For assay of wound contamination as infection index, wounds were swabbed every 3 days and positive culture assessed as positive for wound microbial contamination according to the standard microbiological lab procedures. Also body temperature were assessed as infection index. High body temperature or fever mostly caused by infection(5). Body temperature were registered 3 times per day. Pain assessment was according to the use of pain killers which was prescribed based of patient uncomfortable and demands.
Results:

Age distributions were between 5 to 52 in both study group and it was \( \frac{67}{9} \pm \frac{16}{7} \) in experiment group(silver dressing) and \( \frac{62}{6} \pm \frac{11}{7} \) in control group \((p=0.99)\).

Sex distribution was according table1.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Experiment(Agicoat)</th>
<th>Control(Sulfadiazine)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Man</td>
<td>24</td>
<td>%68/6</td>
</tr>
<tr>
<td>Woman</td>
<td>6</td>
<td>%17/1</td>
</tr>
<tr>
<td>Pediatric</td>
<td>5</td>
<td>%14/3</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>%100</td>
</tr>
</tbody>
</table>

Table 1: Sex distribution in both experiment and control group \((p=0.99)\).

Burn wounds were classified by burning cause which were hot liquids, fire and others. Table 2 shows the statistic data.

<table>
<thead>
<tr>
<th>Burning cause</th>
<th>Experiment(Agicoat)</th>
<th>Control(Sulfadiazine)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Hot liquid</td>
<td>7</td>
<td>%20</td>
</tr>
<tr>
<td>fire</td>
<td>26</td>
<td>%74/3</td>
</tr>
<tr>
<td>others</td>
<td>2</td>
<td>%5/7</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>%100</td>
</tr>
</tbody>
</table>

Table 2: Burn wound causes \((p=0.51)\).
Percentage of burn wounds to total body surface distributed in 2 groups was according table 3.

<table>
<thead>
<tr>
<th>Burn area(percentage of body surface)</th>
<th>Experiment(Agicoat)</th>
<th>Control(Sulfadiazine)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
</tr>
<tr>
<td>10-15</td>
<td>9</td>
<td>25/7</td>
</tr>
<tr>
<td>16-20</td>
<td>7</td>
<td>20/1</td>
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<tr>
<td>21-25</td>
<td>6</td>
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<td>26-30</td>
<td>6</td>
<td>17/1</td>
</tr>
<tr>
<td>31-35</td>
<td>4</td>
<td>11/4</td>
</tr>
<tr>
<td>36-40</td>
<td>3</td>
<td>8/6</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3: Percentage of burn wounds to total body surface.(p=0.8)

There are two most important factor which have great impact on the protocol assessment, they are average hospitalization days and administrated narcotic pain killer medicine for each groups.

Figure 1: Average hospitalization days its relation to treatment protocol.(p=0.004)
As a index for infection related fever the average number of registered fever to total number of body temperature registration were calculated and are shown in figure 3. Also positive culture from patient wounds were taken by swabbing method shows another evaluation for antimicrobial efficacy of each treatment protocols in figure 4.

Figure 2: Average administrated narcotic doses in experiment and control groups. (p=0.001)

Figure 3: Fever index (fever registration to total body temperature registration) for both groups. (p=0.046)
Figure 4: Average positive culture to total microbiological culture by swabbing methods from wound surface as index for wound contamination. (p=0.00)

As final statement results showed total cost of agicoat wound dressing compare with method, silver sulfadiazine and statistics calculation shows lower cost in contrast to higher agicoat dressing initial cost.

Figure 5: Average total cost for burn treatment. (p-value: 0.06)
Discussion:

In this study we try to evaluate candidate patient for silver sulfadiazine and silver dressing burn treatment in equal condition like as sex, number, age, burn cause and area percentage. According to table 1, 2, 3 and statistic calculation of p-value by "indepented t-test", "Mann-Whitney U test" and Kai-score, there are no significance different for all mentioned factors in both group. Such selections were prohibited later statistically errors in our finding in this study.

Figure 1 shows an interesting finding due to use of silver dressing, less hospitalization days 9.7 compare to silver sulfadiazine treatment protocol 15.7 days. There are some hypothesis behind our finding, first one is less aggressive dressing changing by agicoat silver dressing or other equal type of dressing. In fact silver sulfadiazine should recover 2 to 3 times per day but new silver dressing technology remain on wound for several days, by every days change of dressing the epithelial layar which is responsible for repairing of damaging dermal tissue will be removed by mechanical force of wound cleaning or adhesion to the dressings materials and it would be one of reason for slow recovery of burn wounds in silver sulfadiazine cases. 

In another embodiment wet environment that is required condition for use of access to nutrition and oxygen. Also silver release from dressing could improve the wound healing by killing microorganisms which are responsible for inflammation and retarding the healing process. Figure 3 shows in silver dressing cases; there are less probability for wound microbial contamination and it might be an indication for such findings. From another point of view less fever registration in experiment group (figure 4) show less inflammation which produces by foreign particle such as microorganisms. All above mentioned reasons could tell us why patient with silver dressing could shorten the hospitalization period and improve the healing process.

Use of less pain killer medicine (figure 2) in experiment group come from less days in hospital and less pain. Lower pain might be as reason of less interfering in wound area which is highly sensitive. In conventional methods like as silver sulfadiazine is common to every day cleaning and changing of environment of wound which is produced as result of using silver dressing prevents skin dryness and easy removing of dead tissues, improve vascular, better access of immune system and finally better wound healing compare to conventional method. Improvement of wound scare is another important advantage of using wet silver dressing that is very important to mental recovery of burn patient and will have great impact on future life quality from cosmetic point of view.

Cost is another important factor in caring systems. According our analysis that is high lighted in figure 5 total cost is less than conventional method interestingly. However initial prices of silver dressing is a lot higher than silver sulfadiazine but less nursing cost as result of less dressing changes, lower hospitalization days, less uses of antibiotic and narcotic pain killer medicine reduce the overall cost more than conventional method.
Conclusion:

In this study we try to compare using silver nanocrystalline wound dressing technology to conventional silver sulfadiazine method. According our finding using such technology could improve overall patient health quality and reduce the cost of caring system.

Acknowledgement:

Thanks to Emam musa kazem Hospital, Esfahan university of medical science employees for cooperation in this study and Emad pharmaceutical Co. for providing us free dressing of running the study.

Ethical issues: However Agicoat approved by Iranian food and drug administration for use on wounds, all patients incorporate in this study announced before entering to study and give us sighed permission.

References:

Silver wound dressing: Agicoat Versus Acticoat, invtro study

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Abstract

Silver dressing are one of the most developed dressing in recent decay because of its antimicrobial properties in wound infection management in this study we try to compare a new introducing brand in our nation Iran Agicoat to well known Acticoat silver dressing in both physical properties and antimicrobial efficacy. Our results shows both dressing have nano structural silver coating on their carrier and present comparable antibacterial properties against gram positive and gram negative bacteria. Although they were a bit different in MIC and MBC for gram type bacteria. Silver nitrate as source of silver ion select as reference standard in this study.

Keywords: Silver, Dressing, Antibacterial
Introduction
One of the most recently silver products that are increasingly being used to cover burn wounds, traumatic injuries, skin graft, diabetic ulcers, incision, abrasion and minor cuts are silver dressings.(1,2)
As well known use of silver preparations for example silver base cream, silver impregnated polymeric medical devices such as catheters and heart valves are common today.(3,4,5) Coating the polymers with metallic silver is the most practiced to produce silver dressings. Some of new commercial products being used are Acticoat, Silverlon and Agicoat. Acticoat is a silver coated high density polyethylene polymer sheet(6) and silverlon as well as Agicoat are woven silver coated nylon fabrics(9). Difference claim about silver nylon dressings and Acticoat e.g. surface morphology and antibacterial properties was promotion for this study better compare Agicoat as silver nylon dressing and Acticoat.

Material and methods

Dressings
Acticoat wound dressings with two layer of high density polyethylene (HDPE) polymer sheet welded to layer of polyester nonwoven textile as absorber were produced as sterile sample 10 cm*10 cm square centimeter by smith & nephew medical LLC (England). Agicoat wound dressings with single layer silver coated woven nylon textile were produced as sterile sample 10 cm*10 cm square centimeter by Emad pharmaceutical Co (Iran).

Reagents
Nitric acid 65% extra pure (Merck), Silver nitrate powder extra pure (Merck), soybean casein digest broth (tryptic soy broth, T8907, Sigma-aldrich), Soybean casein digest agar (tryptic soy agar, T4536,Sigma-aldrich) were used.

Labware
Scanning probe microscope (SPM) and related software (dualscope™ FROM Danish Micro Engineering Co, Denmark), Scanning electron microscope (Zeiss, Germany), microbiology glass ware such as tubes, pipettes and other were sterilized in an oven for 3 hours. Gamma sterilized polyester culture test plates were used also shaker-incubator and electronic balance with 0.1 mg resolution.

Scanning of dressing sample
Acticoat layers were laminated to three separate layers and the HDPE silver coated layer was scanned through the SPM. Because of the homogeneity of silver nylon dressing "Agicoat" the sample was scanned with out any processing. For better illustration the macro structure of these dressings, images were taken. Two dressing scanned with SEM with out any future processing.

Silver content analysis
The silver weight per square centimeter was analyzed with gravimetric method, 25 square centimeter of both dressing were weighted and after dissolution of silver in 10% nitric acid and drying they were weighted again. The difference between two weights was reported as silver content. In Acticoat, all calculations e.g. silver content. Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) stand on one layer silver coated polymer sheet.
Determination of MICs and MBCs

Four strains of microorganisms S. aureus (ATCC 6538), S. epidermidis (ATCC 2222), E.coli (ATCC 3987) and P. aeroginosa (ATCC 9027) were used as test organism. For determination of MICs first 1 ml of inoculated soybean casein digest broth (SCDB) that were sterilized before use, were purled in sterile glass tubes, then added metered and weighted slices of both dressing to each one in descending manner and tubs were incubated for 24 hours at 37 degree of centigrade. The last non turbid tube was reported as MIC. By this method the MIC of ionic silver (as silver nitrate) was determined. The MBCs were determined by adding 5 micro liters of non turbid tubes to soybean casein digest agar (SCDA) plates and were incubated for 24 hours in same condition as MIC test. The highest related concentration of silver that was not contaminated were reported as MBC.
<table>
<thead>
<tr>
<th></th>
<th>S.aureus (MBC/MIC)</th>
<th>S.epidermid (MBC/MIC)</th>
<th>E.coli (MBC/MIC)</th>
<th>P.aeroginosa (MBC/MIC)</th>
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<tbody>
<tr>
<td>Acticoat</td>
<td>132/733</td>
<td>100/600</td>
<td>84/100</td>
<td>84/117</td>
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<td>Agicoat</td>
<td>33/500</td>
<td>92/250</td>
<td>233/275</td>
<td>104/350</td>
</tr>
<tr>
<td>Ag$^+$ (as nitrate)</td>
<td>10/13</td>
<td>10/19</td>
<td>10/10</td>
<td>7/19</td>
</tr>
</tbody>
</table>

Table 1: MICs and MBCs (µg silver/ml) results for Acticoat, Agicoat and silver ion.

**Discussion:**

MICs and MBCs data indicate the bactericidal and bacteristatical properties of both dressings as well as silver ion but comparison of antibacterial concentration of this form of metallic silver with ionic ones shows the weaker antibacterial properties for dressing in this study. In the other other hand, The metallic silver deposite on the dressings were stabilized and solid, because of this reason the antibacterial activity of dressings wer done by dissolution of metallic silver to ionic silver. Electrochemical corrosion of nano structural silver surface with large contact area may act as dissolution promoter. The difference between bactericidal concentration of silver dressings and silver ion indicate the above theory.

Comparison of MIC and MBC for each dressing shows that the MICs concentrations less than MBCs but the concentrations difference for ionic silver were tiny. Slow dissolution rate of metallic silver is one of key factor for the difference that omitted for silver nitrate as ionic silver. SPM and SEM images of wound dressings (figure 1 and 2) show the surface roughness and porosity of both dressings were in nanometer scale.

Dissolution rate is an important factor for silver dressing efficacy(10) and the contact surface area and primarily loading dose play the key roles in the dissolution rate (9), macro and micro structure of both dressings are important because of their roles in surface area, for above reasons and by comparison of the macro size images of both dressings in figure2, the little difference between MICs and MBCs of dressings could be seen because in Agicoat larger surface area was available and Acticoat much initial silver was loaded. In both dressings the micro surface area became larger than normal metallic silver by nanotechnology advances.

Some references reports less effectiveness for silver dressings(7,8). But it seems the slow dissolution of silver from the dressings (10) and correct use of them such as wetting the wound and dressing area and use the sufficient layers of dressings produced are the reasons also use systemic antibiotics for infected or deep wounds are recommended because of slow penetration of ionic silver throw tissues.

Our study shows both dressing are effective against common pathogen and potentially will be useful in wound management.
References:

General instruction and precautions

**Wound contact dressings**

Advanced antimicrobial wound protection

Clinical protocol

The Agicoat wound contact dressing is designed to be a multi day antimicrobial post surgical barrier wound dressing,and is designed to be placed in primary contact with the surgical incision. The Agicoat surgical wound dressing is composed of a wound contact layer of Agicoat. The Agicoat wound contact layer is a specially designed flexible knit polymeric fabric 1005 coated with a layer of pure metallic silver. The layer is composed of an 8 ounce (per square yard) medical grade nylon.

**General precautions:**

-for external application only, remove prior to MRI scanning
-store at room temperature, avoid temperatures above 122°F (50°C)
-Dressings are **not** compatible with: betadine or antibiotic ointments, products containing saline, chlorine, petrolatum, iodine, or hydrogen peroxide.

-The Agicoat surgical wound dressings have been reported to reduce the pain from acute incisions with a reduction in wound pain, some patients will have a tendency for over activity prior to stability of the wound site.

**Initial Wound Dressing:**

The initial wound dressing is to be applied in the operating room as follows:
- Cleans the incision with **sterile water** and remove **betadine** and **ointments**
- remove the dressing from the pouch
- saturate the Agicoat surgical wound pad in a basin with sterile water-DO NOT USE SALINE.
- remove excess water from the pad by gently squeezing
- Apply Agicoat surgical dressing directly to the surgical incision, centering the silver pad over the incision overlapping per wound skin by 1 cm or more is beneficial.
- additional absorptive dressings may be placed over the Agicoat CV surgical wound dressing.
- Hold Agicoat wound dressing in place with tubular stretch knit, tape or compressive wrap

**General wound examination and dressing maintenance**
The wound may be examined by gently lifting up the dressing, examining the wound, and returning the same dressing. For optimal results, maintain the dressing in moist condition and free of exudates buildup.

**Directions continued (over) wound dressing change at 72 hour or at discharge:**

Using professional discretion, as noted below, the first dressing change should be at 72 hours or at discharge in the CMU or the ICU.

- To remove, gently lift the dressing from the wound surface. If adhering to the wound, re-saturate the dressing with sterile water from the perforated backing layer side.

- Replace initial dressing with another Agicoat surgical wound dressing to preserve barrier.

- If free from buildup, this dressing may stay in place until office follow up or suture removal (7 to 14 days post discharge per physician protocol).

**Additional Non-scheduled wound dressing changes per professional discretion:**

Additional Non-scheduled wound dressing changes may be indicated for the following conditions:

- Dressing and/or additional covering absorptive dressings saturated with blood.

- Systemic body temperature elevation greater that 102°F×2 consecutive (4 hour interval).

- Purulent drainage from the wound site.

- Odor from the wound site.

**General contraindications:**
Agicoat dressing are contraindicated for patients with known sensitivity to silver or nylon
SEM pictures from Agicoat to surface cover with nano crystals of Silver
Agicoat Invitro Antibacterial Evaluation