

Comparison of silver nylon wound dressing and silver sulfadiazine in partial burn wound therapy

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ABSTRACT

The study aims to perform a comparative assessment of two types of burn wound treatment. To do the assessment, patients with partial thickness burn wounds with total body surface area <40% were simple randomised to treat with nanocrystalline silver nylon wound dressing or silver sulfadiazine cream. Efficacy of treatment, use of analgesics, number of wound dressing change, wound infection and final hospitalisation cost were evaluated. The study showed silver nylon wound dressing significantly reduced length of hospital stay, analgesic use, wound infection and inflammation compared with silver sulfadiazine.

Key words: Burn wounds • Silver sulfadiazine • Silver nylon wound dressing

INTRODUCTION

Burn wounds need to be healed and re-epithelialised as soon as possible in order to prevent infection, reduction functional, dysfunctions and cosmetic after effects (1). Burn wounds have higher chance of bacterial

infection because of accumulation of dead tissues, compromised immune system and blood supply and then infection is one of the major reason of death after burn injuries (2). Silver sulfadiazine (AgSD) is one of the conventional therapeutics which have been used for long time (3), but there are some reported adverse effects which increase the demand of new therapies and technologies in burn wound management (4).

Silver has been known to have bactericidal properties and it was in core of many studies for several years (5). Silver recently gaining renewed attention to treat bacterial infection and preventing wound sepsis in different prescription forms in conjunction with other materials such as wound dressings which impregnated with silver salts or metal nanoparticles (6–8). One of the silver products that is increasingly being used to cover burn wounds, traumatic injuries, skin graft, diabetic ulcers, incision, abrasion and minor cuts are silver dressings (9). Metallic and ionic

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Key Points

- in this study, the efficacy of Agicoat[®] was evaluated and compared with the AgSD as a conventional protocol for burn wound treatment in most of Iranian burn clinics
- the study aims to evaluate the total hospitalisation cost, wound healing rate, analgesic use, fever as inflammatory index and total aerobic bacterial wound contamination for both therapies
- 185 patients with partial-thickness burn wounds who were treated at 'Imam Musa Kazem' burn hospital were reviewed for inclusion into the study

silver was used in variety of medicine and medical device such as topical creams, emulsion, catheters and medical prosthesis (10–15). However, there are different methods used to impregnate wound dressings with silver compound, but coating a textile, fibre or polymer mesh with a layer of nanocrystalline silver resulted in sustain release and long-acting antibacterial wound dressings (9,16). In 1998, Tredget *et al.* (17) showed the safety and efficacy of a nanocrystalline silver-coated polyethylene mesh to prevent the infection in burn wounds by reducing bacterial burden; although anti-inflammatory mechanisms of nanocrystalline silver is not clear (13), it might reduce inflammation by fighting the bacterial infection (18) – an important reason for persistent inflammation which leads to infiltration of neutrophils and elevated matrix metalloproteinases (MMPs) in infected wounds. MMPs play a role in the controlled degradation of extracellular matrix. It has been shown that nanocrystalline silver and its derivative solution has anti-inflammatory effects; for instance, a study suggested that MMPs level is reduced in the presence of nanocrystalline silver dressing; elevated activities of these enzymes may lead to excessive extracellular matrix destruction. Also nanocrystalline metallic silver dressings can suppress MMP-9 activity and reduce TNF- α levels in the wounds (19–21).

Silver dressings like Acticoat[®] (Smith & Nephew, Largo, FL), a high density polyethylene mesh coated with nanocrystalline silver and silver oxide by physical vapour deposition technique (22), Silverlon[®] (Argentum LLC, Chicago, IL) and Agicoat[®] (Emad pharmaceuticals Co., Esfahan, Iran) – a woven silver-coated nylon fabrics in which silver is deposited on nylon fibres by autocatalytic electroless deposition techniques (23), are among metallic silver dressings which sustain silver release. Since their manufacturing methods are different from Acticoat[®] to Silverlon[®] and Agicoat[®], the nanocrystalline structure and physical properties of silver crystals are distinctive in them. These morphological and chemical differences resulted in different silver release profile in Acticoat[®] and Silverlon[®] in terms of duration and net silver release rate; however, these wound dressings show acceptable antimicrobial properties *in vitro*. Agicoat[®], a less studied brand, also

has silver release profile similar to its counterpart Silverlon[®] with approximately 600 mg/100 cm² of silver. It can release silver for long time and show antimicrobial effectiveness.

In this study, the efficacy of Agicoat[®] was evaluated and compared with the AgSD as a conventional protocol for burn wound treatment in most of Iranian burn clinics. Although using such a dressing in burn wounds is not new for some brands such as Acticoat[®], the study investigates the efficacy of a brand new silver nylon wound dressing which was recently introduced to Iran and international market. The study did not compare Agicoat[®] with Acticoat[®] which is less available in Iran market due to its high prices therefore most burn clinics and patient prefer to use AgSD as a standard burn wound treatment protocol. The study aims to evaluate the total hospitalisation cost, wound healing rate, analgesic use, fever as inflammatory index and total aerobic bacterial wound contamination for both therapies.

MATERIALS AND METHODS

Patient population

Between April 2010 and July 2011, 185 patients with partial-thickness burn wounds who were treated at 'Imam Musa Kazem' burn hospital were reviewed for inclusion into the study; then 69 of them were treated with silver nylon wound dressing or AgSD cream until complete wound closure which was defined by complete epithelialisation. The inclusion criteria were partial-thickness burn wounds, <24 hours post-burn injury and total body surface area (TBSA) between 10% and 40%. Exclusion criteria were full thickness burns, pregnancy, immunocompromised patients, patients with known hypersensitivity to silver and its compounds, comorbidity (e.g. diabetes, cardiac or renal disease), chemical or electrical burns, multiple trauma and age <5 and >60. Selected cases were categorised by age, sex, burn type and burn percentage. In all cases, informed consent was obtained from patients or their relatives. Both clinician and patients or their relatives were aware about the treatment procedure (open label design). The study protocol was approved by the ethical committee of Imam Musa Kazem Hospital, Esfahan University of Medical Sciences, Esfahan, Iran.

The study dressing

Agicoat® comprises patented silver-coated woven textile that sustains released silver ion from the deposited nanocrystalline silver cluster on the textile fibres. This thin woven textile needs to be supported by an additional occlusive dressing on wound with cotton gauze or pads. According to the manufacturer information, the silver was deposited by autocatalytic electroless silver deposition onto the nylon fibres. It continuously releases silver ion and shows antimicrobial effectiveness up to 7 days according to the data represented by the manufacturer and approved by Iran food and drug organisation (unpublished data). Agicoat®, an approved wound dressing by Iranian food and drug organisation for use on all kinds of wounds, was used to provide an antimicrobial effectiveness and barrier by lowering the risk of infection in contaminated, moist or high exudate burn wounds.

Wound dressing protocol

In Agicoat®-treated group, the treatment consisted of the application of silver dressing. Agicoat® silver dressing was applied directly on wounds, thereafter it was covered by cotton gauze and wetted regularly by sterile water. It must be wet, according to the manufacturer instruction. In case of high exudate wounds, just oversaturated cotton gauzes were changed. The Agicoat® dressings were changed every 7 days until complete wound closure and healing. All patients were followed up in hospital until the end of study and final examination. Wounds assumed to heal, when all areas of initial injury had fully re-epithelialised. The other group received 1% AgSD cream which was covered with cotton gauze. AgSD dressings were changed every day until wound closure.

Study design and evaluation criteria

Sixty-nine burn wounds patients were included and randomised (the random number generator was used) into two groups and given burn wound treatment with 1% AgSD or Agicoat®; 35 patients as subject using silver nylon dressing and 34 patients as control treated by AgSD. Two burn wound surgeons filled a demography form for incoming patients to the program. The surgeons recorded type of burn wound, location of wound, size (length × width in centimetres), depth of wound and amount of

wound exudates. Both groups were compared with regard to the patient demographic data. The photographic records were performed for all the burn wounds. Efficacy of treatment was evaluated by average number of analgesic doses, which was prescribed based on the patient demands and assessed by visual analogue scale, number of wound dressing change, nursing time and time of burn wound healing between both groups. As fentanyl was the only analgesic medicine which was approved by the hospital regulatory for acute pains of burn patients, the number of its dose was considered to be a good measuring scale for comparison and assessment of the acute pain in both groups.

Wound contamination for aerobic micro-organisms was assessed according to the described methods (24,25) every 3 days. Briefly, swabs were immersed in 0.5 ml sterile normal saline and after wound swabbing they were cultured on soybean casein digest agar plates immediately by surface culture method and were incubated for 48 hours. Visible colonies on plates were counted and reported as total count. Also body temperature was registered three times per day. The anaerobic micro-organisms did not count due to the technical limitation.

The final hospitalisation cost was evaluated according to the cost of antibiotics, analgesics, dressings and hoteling costs which included nursing and visiting costs.

Statistical analysis

All data were expressed as mean ± SD. For parametric data, Student's independent *t*-test was used to compare data; for nonparametric data, Mann-Whitney test was used. Chi-square test was performed to determine the relationship between parameters. Significance was defined as a *P* value of <0.05.

RESULTS

Sixty-nine patients were recruited: 24 males and 11 females in the Agicoat® treatment group, and 23 males and 11 females in the 1% AgSD treatment group (*P* = 0.99), respectively, with approximately 119 000 and 112 000 cm² total treated burn area. The TBSA burn percent was not significantly different in both groups (*P* = 0.8). Age distributions were between 5 and 52 in both the study groups and the mean

Key Points

- sixty-nine burn wounds patients were included and randomised (the random number generator was used) into two groups and given burn wound treatment with 1% AgSD or Agicoat®
- 35 patients as subject using silver nylon dressing and 34 patients as control treated by AgSD

Table 1 Demographic data of the patients in both groups

	1% Silver sulfadiazine treatment group (N = 34)	Agicoat® treatment group (N = 35)	P value
Age (years)	27.9 ± 12.7	26.2 ± 11.7	0.99
TBSA burn (%)			0.8
10–15	23.5%	25.7%	
16–20	14.8%	20.1%	
21–25	23.5%	17.1%	
26–30	20.6%	17.1%	
31–35	8.8%	11.4%	
36–40	8.8%	8.6%	
Sex			0.99
Male	67.6%	68.6%	
Female	32.6%	31.4%	
Type of burn injury			0.51
Hot liquid	14.7%	20%	
Fire	73.5%	74.3%	
Others	11.8%	5.7%	

TBSA, total body surface area.

Key Points

- long antimicrobial effectiveness of Agicoat® silver nylon dressing and others sustain the release of non crystalline silver wound dressings make them superior in wound healing
- they help regeneration and re-epithelialisation of burn wounds, minimise patient's pain, extra trauma during dressing changes, reduce healing time and hospitalisation period
- using of Agicoat® in moist environment which is a mandatory condition for administration of this silver nylon dressing improves wound recovery

age of patients was 26.2 ± 11.7 in Agicoat® group while it was 27.9 ± 12.7 ($P = 0.99$) in the 1% AgSD group. Burn wounds were also classified by burning causes which were hot liquids, fire and others which was the same in both groups ($P = 0.51$). Demographic data of the patients in both groups are shown in Table 1. All patients remained in the study till complete wound healing and nobody left before ending the study because of unwanted reaction, death or dressing's adverse effects.

The Agicoat® treatment group had manifested significantly lower analgesic doses scores than the 1% AgSD-treated group ($P = 0.001$). Average number of days with fever (2.9 for Agicoat® and 6.3 for AgSD) to total number of body temperature registration (34 for Agicoat® and 59.2 for AgSD) also was less for Agicoat® group significantly ($P = 0.046$). Also positive culture regarding micro-organisms was less for Agicoat® (82 positive cultures out of 200 culture) compared to 1% AgSD treatment group (142 positive cultures out of 200 culture, $P = 0.001$). The data are summarised in Figure 1. Finally, comparison of total treatment cost showed no significant difference between two groups ($P = 0.06$; Figure 2).

DISCUSSION

Partial-thickness burn wounds are difficult to manage. Wound infections, elevated levels of

pain and delayed wound healing are main problems to deal with.

In previous studies, AgSD, an inexpensive medicine, had been shown its efficiency to reduce the risk of infection (26). AgSD was a broad spectrum topical antimicrobial agent which was active against Gram-positive cocci like as *Staphylococcus aureus* and Gram-negative bacilli, particularly *Pseudomonas aeruginosa*. It has been used as standard treatment protocol in partial-thickness burn wounds for several years. Therefore, it is compared as standard protocol to an available, rather low price nanocrystalline silver nylon wound dressing Agicoat®.

Partial-thickness burn wounds are challenging because of the long healing time and periodical wound dressing changes which hurts and slowdown the wound healing. Therefore, daily changes of AgSD dressing with associated pain and risk of nosocomial infections are higher than Agicoat® which needed longer time to change. As results of fewer dressing changes in Agicoat® treatment group, less pain accompany with use of Agicoat® dressing which favoured the patients. This directly results in fewer analgesic doses compared to AgSD treatment group. However, previous studies have shown that nanocrystalline silver dressings have analgesic properties (27,28), but this study did not evaluate pain as independent value and compare the specific pain reduction of the studied dressing to AgSD; for instance, our evaluation cannot show either less number of dressing change caused by the lower administration doses of analgesic or silver dressing analgesic properties.

Long antimicrobial effectiveness of Agicoat® silver nylon dressing and others sustain the release of non crystalline silver wound dressings make them superior in wound healing. They help regeneration and re-epithelialisation of burn wounds, minimise patient's pain, extra trauma during dressing changes, reduce healing time and hospitalisation period (Figure 1). Also using of Agicoat® in moist environment which is a mandatory condition for administration of this silver nylon dressing improves wound recovery. Winter has described 'The idea of moist healing'. He mentioned that healing would proceed two times faster in a moist environment than under a scab (29). The main target of moist wound therapy is to maintain optimal wound-healing condition. Although

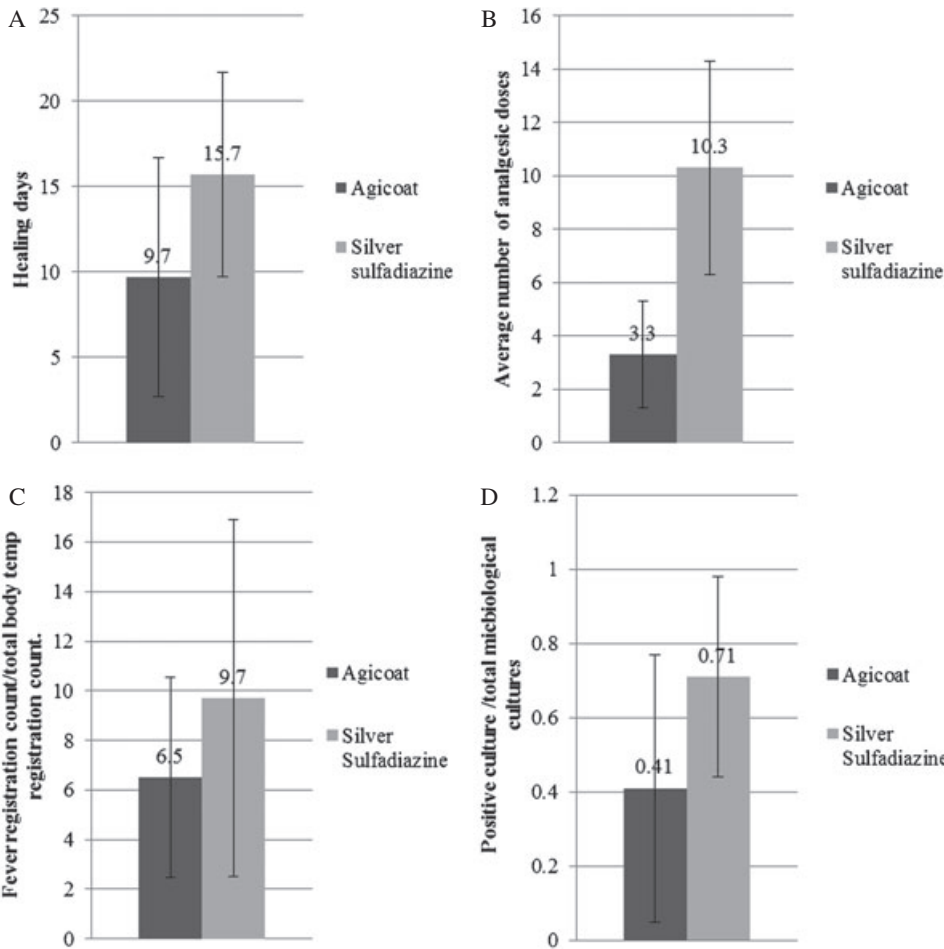


Figure 1. (A) Average healing time (days) in Agicoat® and silver sulfadiazine group ($P = 0.007$). (B) Average administrated narcotic analgesic doses in Agicoat® and AgSD group ($P = 0.001$). (C) Fever index (fever registration to total body temperature registration) for both groups ($P = 0.046$). (D) Average positive contaminated culture to total microbiological culture ($P = 0.001$).

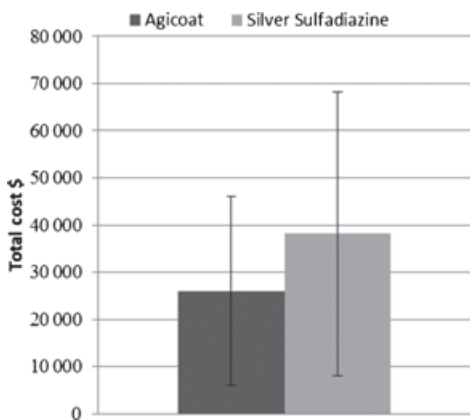


Figure 2. Average total cost for burn treatment protocols, the cost calculated according to US dollar ($P = 0.06$).

moisturised wound environment increased bacterial infection risk, moist wound treatment was accepted to prevent scar formation (30).

Therefore, silver release from dressing could improve wound-healing progress by reducing infection rate which is one of the major factor for inflammation and retarding healing process (18). Finally, it has been shown that total costs of both dressings are not significantly different, mostly because of higher initial cost (dressing cost) of Agicoat® although it decreases the frequency of dressing changes and nursing cost.

CONCLUSION

Agicoat® advanced antimicrobial silver nylon wound dressing is an effective barrier against microbial penetration in partial-thickness burn wounds. The study results suggest that it significantly decreases the analgesic use, risk of infection, fever as inflammatory index and the healing time compared with 1% AgSD

Key Points

- silver release from dressing could improve wound-healing progress by reducing infection rate which is one of the major factor for inflammation and retarding healing process
- it has been shown that total costs of both dressings are not significantly different, mostly because of higher initial cost (dressing cost) of Agicoat® although it decreases the frequency of dressing changes and nursing cost
- the presented data show that Agicoat® could be used as an effective dressing to manage partial-thickness burn wounds

treatment group. The presented data show that Agicoat® could be used as an effective dressing to manage partial-thickness burn wounds.

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