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Original Article

Surgery Section

Evaluation of Nano-Crystalline Silver Dressings in Superficial Partial Thickness Burns

ANSHUL JAIN[1], JAFAR HUSAIN[2], AJIT SINGH[3]

ABSTRACT

Introduction: Silver as an antimicrobial agent has been known for the treatment of burns. Silver nitrate causes discoloration of skin and silver sulphadiazine causes tissue irritation and pseudo-eschar formation. Nano-crystalline silver dressings were a significant break-through in the management of burn wounds.

Aim: To assess the efficacy of nano-crystalline silver dressing in management of second degree superficial burns.

Materials and Methods: Thirty patients suffering from second degree superficial burns of different aetiologies were treated and wound healing was closely monitored with regular photographic evidence.

Results: The mean score of pain using numeric and faces pain rating scale was 7.36 at the time of admission. Eighteen patients didn't have pain at one week. Mean score of remaining 12 patients was 1.5. When the total score is divided by 30 (18+12), then mean pain was 0.6. The mean number of dressing changes required was 4.73. Burn wounds of four patients epithelialised completely within one week requiring no more dressings, whereas 18 patients took up to two weeks and eight patients required more than two weeks for epithelialisation. However, complete healing was observed in all patients at four weeks and at three months follow-up, the scar was supple with no evidence of raised skin or hypertrophy.

Conclusion: The ease of use, powerful antibacterial effect, lower frequency of dressing change, good molding, short time of wound clearing and epithelialisation, and painless dressing change are the advantages of nano-crystalline silver dressing which provide reasons to consider it as highly efficient for application in superficial burns of second degree.

Keywords: Dressing change, Healing, Second degree

INTRODUCTION

In India over 1,00,00,00 people get moderate to severe burn every year [1]. The principles in the treatment of burn injuries are control of pain, adequate maintenance of fluids and electrolyte balances, prevention from early burn shock, prevention and control of infection and achieve an early wound healing. Wound dressings minimise the loss of fluid and electrolytes, reduce the pain and prevent contamination from external environment.

Though the ideal dressing is autologous split thickness skin graft, these are not always feasible in cases of massive burns due to non-availability of donor areas. Also, in cases of partial thickness, burns, as variable amount of dermis and dermal adnexa are intact, there are chances of spontaneous wound healing, unless the wound is converted into full thickness burns, either because of infection or ischemia from burn shock. So it is essential to have an appropriate material in burn dressing that should improve healing with control of local infection.

Conventionally, a thick layer of 1% Silver Sulfadiazine (SSD) cream is applied over the wound, which is covered with paraffin gauze and a layer of gamgee pads. These are to be changed daily or more frequently, depending on the amount of soakage. Agents like collagen sheets do not have anti-microbial properties.

Silver as an antimicrobial agent has been known and various silver containing dressings are used for the treatment of burns. Silver nitrate causes discoloration of skin and SSD causes tissue irritation and pseudo-eschar formation. The most frequently associated clinical finding is transient leucopenia which occurs within several days of the initiation of therapy [2]. In addition, the ionic silver released by these dressings is rapidly de-activated by wound exudates mainly by chloride ions, thus requiring frequent applications [3]. In late 1990s, nano-crystalline silver dressings were introduced for the management of burn wounds. It was developed to overcome limitations of former dressings by releasing silver for up to 7 days in a sustained fashion. The non-charged form of silver in this reacts more slowly with the chloride ion and thus is de-activated less rapidly in wounds.

Nano-crystalline silver dressing supplies free silver ions and radicals in a durable and consistent manner in a moist environment on the surface of burn wound. Its antibacterial effect is swift and powerful despite releasing 30 times less silver than silver nitrate and SSD. The spectrum is wide to include Gram positive and Gram negative bacteria, aerobes, facultative anaerobes and fungi; as well as *Pseudomonas*, MRSA and VRE [4]. The action starts within 30 minutes and lasts up to 3 days [5]. Five bacterial strains of clinical interest were used to determine and compare Minimum Inhibitory Concentration (MIC) and the Minimum Bactericidal Concentration (MBC) of 4 dressings viz. Acticoat, $AgNO_3$, Mafenide acetate and SSD [6], and the nano-crystalline silver dressing was found to have the lowest MIC and MBC as compared to the rest three silver dressings.

A systematic review and meta-analysis of nine studies which compared nano-crystalline silver with alternative silver delivery system by Nherera LM et al., suggested that the use of nano-crystalline silver dressings resulted in reduced pain, lesser number of surgical procedures, decreased length of hospital stay and fewer infection incidents when compared to SSD, $AgNO_3$ [7].

The present study assessed usefulness and efficacy of nano-crystalline silver dressing (Acticoat®; Smith & Nephew; US) in Indian context with respect to patient tolerance and comfort, as there are no studies from Indian centers with this dressing. It tries to create a database of an Indian hospital about the experience with a modern dressing for treatment of second degree superficial burns.

MATERIALS AND METHODS

This prospective cohort study was conducted at a tertiary care center in an armed forces set-up from January 2013 to February 2014, wherein 30 patients suffering from second degree superficial burns of different Total Burn Surface Area (TBSA) were treated.

Exclusion Criteria

1. Patients with first degree and deep burns
2. Patients with sepsis
3. Those with inhalational injuries

All patients were included in the study after obtaining a signed informed consent from the patients or from their legal guardians and the study protocol was approved by the hospital ethical committee (ECC/12 dt 01 Oct 12).

The extent of the burn injury in percentage of TBSA involved was assessed by the Lund and Browder chart [8]. Initially, the patient was resuscitated with adequate fluids based on the modified Parkland's formula. The severity of pain at initial presentation was recorded using pain rating scales viz., numeric rating scale and faces pain rating scale.

Thereafter, the wounds were thoroughly cleaned of all loose and devitalised skin, and any dressing material applied before arrival to our centre was removed. The blisters were de-roofed and then a wound swab was collected for baseline culture and antibiotic sensitivity. Subsequently, the wounds were cleaned with copious amounts of sterile isotonic saline.

The wound was mopped dry. The nano-crystalline silver dressing (Acticoat®; Smith & Nephew; US) which was used, consisted of three layers viz., one central and two external. The central layer is made of rayon and polyester, which has absorbent core and regulates discharge of silver. The external layers are high density polyethylene mesh coated with silver. It was soaked with distilled water before application. The dressing was trimmed according to the shape of the treated area. The surface with a bluish tinge (inner surface) was applied directly over the wound and the surface with metallic luster remained outside and applied flat on the wound.

All the involved areas were covered; a layer of sterile gamgee pad was applied over it and a roller bandage was used to secure the dressing. This dressing was inspected every third day provided it was dry and earlier in case it was soaked. The nano-crystalline dressing adherent to the wound surface was not disturbed. Those parts of the dressing that were non-adherent or harboured fluid or pus underneath were removed, the wound was thoroughly cleaned and fresh nano-crystalline silver dressing was applied again in the same fashion as described above.

Wound healing was closely monitored with regular photographic evidence and pain, if any, was relieved by NSAIDs (Non-steroidal anti-inflammatory drugs) or narcotic analgesia if warranted. If fever supervened, it was treated with appropriate systemic antibiotics and antipyretics.

The following investigations were undertaken at the time of admission to the hospital and then as felt appropriate thereafter:

Haematological- Haemoglobin, Total leucocyte count, Differential leucocyte count.

Biochemical- Serum sodium, potassium, urea, creatinine, sugar and proteins.

Microbiological- Wound swab culture, bacterial count to assess the degree of infection, blood culture if indicated.

The adverse events if any during hospitalisation were recorded.

Following points were noted during the process of wound healing for analysis:

1. Patient comfort and degree of pain during dressing changes
2. Development of collection under the dressings
3. Bacterial culture of drained fluids
4. Rate of epithelisation and time taken for healing of the wound
5. Development of break down and fibro-proliferative scars after remodeling.

The patients were followed-up for a mean period of three months. The outcomes assessed were degree and promptness of pain relief, number of dressing changes, duration of hospital stay and type of scar formation i.e., supple, hypertrophic or keloid.

STATISTICAL ANALYSIS

The results of the study were statistically analysed and percentage, mean, median and mode were calculated. Frequency and percentage was calculated for variables like age, sex, mode of burn, number of dressing changes and hospital stay.

RESULTS

[Table/Fig-1] reveals that majority of patients were young children of less than 10 years of age (60%), among which 2/3rd were less than 5 years of age. The two-third patients were males and one-third females, however when distribution was observed in different age group, female patients were almost equal in number to male patients in under 10 years' age group.

Age (in years)	No. of patients	Gender	
		Male	Female
<5	12	8	4
5-10	6	2	4
10-20	2	1	1
20-30	1	-	1
30-40	7	7	-
>40	2	1	1

[Table/Fig-1]: Age and gender distribution.

The most common cause of burn was scalds followed by cracker burst [Table/Fig-2]. The other causes were flash burns followed by thermal radiation burn and flame burn. It suggests the accidental nature of burns in almost all cases, especially in children who form the major group of patients.

Mode of burn	No. of Pts	TBSA	No. of Pts
Scalds	22	<10	21
Cracker burst	4	10-20	4
Flash	2	20-30	1
Thermal radiation	1	30-40	3
Flame	1	>40	1

[Table/Fig-2]: Mode of burns & Total Burn Surface Area (TBSA) as percentage of total body surface area.

The majority of patients (70%) sustained partial thickness superficial burns of less than 10%. Only 5 patients had burn involving more than 20% of body area [Table/Fig-2].

The mean score of pain using numeric and faces pain rating scale was 7.36 at the time of admission and ranged from 0 to 9 (one child had an insensate foot on which she sustained burn), while the mode was 8, which was reported by 13 patients.

At one week after admission, 18 patients did not report pain (0) while the rest 12 complained of only mild discomfort and mean score was 1.5. When the total score is divided by 30 (18+12), then mean pain was 0.6.

The duration for which the nano-crystalline dressing was applied ranged from 6 to 18 days; although 50% of them required it for 10 days or less. The patients who required more than 15 days of dressing had 30% or more burns. The mean duration of application of dressing was 11.5 days. The number of dressings required range from 3 to 8, with 2/3rd of the patients requiring 5 or less dressing change. The mean dressing change was 4.73 [Table/Fig-3].

Days of dressing	No. of patients	No. of dressing changes	No. of pts
5-10	15	3-4	14
10-15	12	5-6	11
15-20	3	7-8	5

[Table/Fig-3]: Number of days nanocrystalline silver dressing applied and number of dressing changes.

All patients showed healing during first week in form of partial epithelialisation and absence of surrounding inflammation. Burn wounds of four patients epithelialised completely within one week requiring no more dressings, whereas 18 patients took up to two weeks and eight patients required more than two weeks for epithelialisation. However, complete healing was observed in all patients at four weeks and at 3 months follow-up the scar was supple with no evidence of raised skin or hypertrophy. 50% of the patients were discharged within two weeks while two patients required admission for more than three weeks. The average stay was 12.18 days for the 22 patients who were admitted, while it is 8.93 days if all 30 were included.

DISCUSSION

An analysis of efficacy of nano-crystalline silver dressing was carried out in this prospective study, where in 30 patients with partial thickness superficial burns were managed. It was realised that the dressing is easy to use, requires less frequent changes, molded well on various body parts with short time of wound clearing and epithelialisation and is efficacious in management of superficial burns of second degree.

Tredget EE et al., found that the frequency of burn wound sepsis and secondary bacteremia was less in the nano-crystalline silver treated group than those treated with silver nitrate. Acticoat was estimated to have a reduction in healing time by reducing the exudates, rate of infection and in frequency of dressing changes [4]. In the present study, there was decrease in exudation and demarcation of Non-vital matter was seen as early as during first change of dressing. The dermis was deeply red, with epithelisation began to appear and there was no inflammation around the wound. A temporary dark brown or grey pigmentation of wound and surrounding skin was observed.

The patients did not feel pain immediately after the dressing application and between the dressing changes. The patients in present study demonstrated prompt pain relief after application of nano-crystalline silver dressing, 18 patients didn't have pain at one week. Mean score of remaining 12 patients was 1.5. When the total score is divided by 30 (18+12), then mean pain was 0.6; which is same as observed by various authors worldwide [4,9-11].

None of the 30 patients showed growth of bacteria on wound swab culture either at presentation or subsequently.

The average number of days for which the dressing was applied was 11.5 days with mean and median number of dressing changes were 4.75 and 5 respectively; the number of daily dressing change comes to be 0.41. A similar rate (0.38) has been reported in a retrospective study [12]. Tredget EE et al., have also reported decreased frequency of dressing changes in their study [4].

In this study, the wounds showed beginning of epithelialisation in the first week with 50% of them epithelialised within 10 days and 90% by two weeks. The mean duration of epithelialisation was 12 days. The result of present study are comparable with other studies, which reported this duration to be 12.98 days and 12±5 days [13,14]. Cuttle L et al., documented that, when patients requiring grafting were excluded, the time taken for re-epithelialisation in the Acticoat treatment group (14.9 days) was significantly lesser than that for the Silvazine (silver sulphadiazine) group (18.3 days) with a p-value of 0.047 [15].

The length of hospital stay has been reported significantly short as 4.5 days, 8.8 days and 3.9 days by Strand O et al., Tonkin C et al., and Jansen LA et al., respectively [12,16,17]. In the present study, the average stay was 12.1 days for the 22 admitted patients and 8.98 days for all patients. However, this centre being a forces set-up, the discharges were done after considering many other variables and not just healing of the wound. Therefore, logically the length of stay is comparable to other studies.

All of the patients in the study group were followed-up to three months. The type of scar formed in each of them was supple, without any hypertrophy or keloid formation.

A recent comparative study from Indian hospital has concluded that use of nano-crystalline silver gel for burns has significant less pain, faster healing and effective control of micro-organisms in wounds [18]. Another comparative study shows that sustained-release silver foam dressing has faster wound healing, lesser pain with earlier hospital discharge than SSD, and lesser expenses when total hospital burden was accounted [19]. There have been no local or systemic adverse effects identified with the use of Acticoat™ [14,20]. The result of various studies using the nano-crystalline dressing is shown in [Table/Fig-4] [4,5,10,14,15,20].

Authors	Type of study	Results
Tredget EE et al., [4]	RCT	The frequency of burn wound sepsis was less in Acticoat™-treated wounds than in those treated with silver nitrate. Secondary bacteremias arising from infected burn wounds were also less frequent.
Wright JB et al., [5]	Bench research	Acticoat™ provided the fastest and broadest-spectrum fungicidal activity.
Fong J et al., [10]	Cohort study	Acticoat™ results in a reduced incidence of burn wound cellulitis, antibiotic use and overall cost compared to Silvazine in the treatment of early burn wounds.
Huang Y et al., [14]	Multicenter RCT	Burn healing times and bacterial clearance was significantly higher with Acticoat™ compared to Sulfadiazine. No adverse reaction to Acticoat™ was found and it is a convenient simple dressing to change, causing minimal pain and does not require to be changed often.
Cuttle L et al., [15]	Retrospective cohort study	Re-epithelialisation time and the percentage of children requiring grafting was significantly less in the Acticoat™ treated group, which is a safe and cost-effective dressing.
Vlachou E et al., [20]	Case series	Acticoat™ is not associated with clinical, biochemical or hematological signs of toxicity.

[Table/Fig-4]: The result of studies assessing nano-crystalline silver dressing (Acticoat™) in burns.

LIMITATION

The study is a single institution, cohort study with limited sample size and does not enjoy benefits of a case-control study or RCT. It also does not assess the cost benefit ratio associated with the nano-crystalline silver dressing.

CONCLUSION

Silver has been an essential modality for treatment of burns. The use of sheets containing nano-crystalline silver has shown to be comfortable to the patient as well as physician as it is easy to use and requires less frequent changes, with effective and timely healing of burn wounds.

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PARTICULARS OF CONTRIBUTORS:
1. Graded Specialist, Department of General Surgery, Armed Forces Medical Services, Leimakhong, Manipur, India.
2. Graded Specialist, Department of General Surgery, Armed Forces Medical Services, Lucknow, Uttar Pradesh, India.
3. Graded Specialist, Department of General Surgery, Armed Forces Medical Services, Dinjan, Assam, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Anshul Jain,
183, Military Hospital, Leimakhong, Manipur, India.
E-mail: anshul163@yahoo.co.in

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