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PEDIATRIC WOUND CARE: A TREATMENT DILEMMA

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ABSTRACT Treating a pediatric-wound requires epitome of expertise especially in neonates. The treating-surgeons usually need to emphasize on multiple-factors. It is very difficult for both surgeon and parents to choose between operative-procedure and non-operative procedure like high quality dressing e.g. nanocrystalline-silver-dressing. The aim of this study is to report nanocrystalline-silver-dressing (Acticoat) as one of good treatment-options for skin-defect-wound especially in neonates and share our experiences gained during the management.

Material & Methods: 20-pediatric patients were treated with acticoat dressing and followed up after 48 hours. If acticoat was dry, we poured distilled water to wet. Gauze-dressing was done over the acticoat. If dressing is soaked and pus was seen trickling, acticoat was reapplied after thorough wash and cleaning. We ensured that there was no foreign body in the wound.

Results: 20-pediatric-patients were treated at this centre with Nanocrystalline-silver-dressing (Acticoat). Out-of-these, 17-patients were infants. 08-were neonates among infants. Burn, trauma, infections and iatrogenic injury are major-etiology. **Mean-sessions-of-acticoat-dressing** and **mean-days-of-treatment** are **3.1** and **17.6 days respectively**. 9-out-of-20-cases were burn-cases with mean-sessions of dressing and mean-days of treatment were **02** and **12.11-days**. Mean-satisfactory-Score of parents was **9.15** (out of 10)**.** We found not a single-case of treatment-failure and not single-case local as well as systemic toxic-effect.

Conclusion: Acticoat is one of the best treatment-options for tissue-defect-wound especially in pediatric-cases and those who are unfit for surgery. Satisfactory-level of parents is very high with acticoat as it can be managed as outpatient. Acticoat-dressing was very effective, relatively pain-free and did not require frequent-change of dressing.

KEYWORDS : Nanocrystalline, Silver, Burns, TIME (tissue, infection / inflammation, moisture balance, edge of wound), SSG Split Skin Graft, SSD Silver Sulfadiazine.

INTRODUCTION:

Treating a pediatric wound requires epitome of expertise especially in neonate. The treating Surgeons usually need to emphasize on multiple factors while managing such wound. These multiple factors drag surgeons into a treatment-dilemma. A Large tissue or skin defect usually invite reconstructive procedure. But parents of pediatric patient especially neonate are usually hesitant for operative procedure. It is very difficult for both surgeon and parents to choose between operative-procedure and non-operative procedure like high quality dressing e.g. nanocrystalline-silver-dressing. Their body surface is too small to take SSG in neonates and infants. So, finding a most suitable treatment is always a challenge for treating doctor or surgeon.

An ideal wound dressing should maintain a moist environment, promote healing, enable gaseous-exchange, protect from secondary-infection, allow ongoing assessment, be comfortable, cause minimal-pain to the patient, result in minimal scarring, be cost-effective and enable removal without causing trauma[1]

Acticoat is a nanocrystalline silver coated non-adherent dressing material which has recently been used as a burn-wound-dressing –[2]. Acticoat has three ply gauze dressing with a core of absorbent-rayon and polyester-coated on each side and has silver deposited polyethylene mesh –[2]. Acticoat creates a moist wound-healing environment and additionally delivers a controlled, sustained, antimicrobial dose (50–100 mg/l) of silver ions to the wound for up to 48 hours following its application –[2]. Hence, Acticoat is a safe and effective dressing usually used for burn wound –[2]. Acticoat has comparatively lower minimum inhibitory concentration, lower minimum bactericidal concentration but faster bacterial killing capacity than silver nitrate, silver sulfadiazine, and mafenide acetate –[3]. Also in many studies, patients after this dressing have reported lesser pain during dressing removal with the Acticoat-dressing than with silver nitrate dressings –[2]. Acticoat is also very effective against fungus –[4].

However, there are very few studies in literature which assess Acticoat for treatment of Pediatric wounds.

The aim of this study is to report nanocrystalline silver dressing (Acticoat) as one of good treatment options for pediatric wound management especially in neonate.

PATIENTS & METHODS:

The present study analysed 20 pediatric cases with tissue defect wound of various etiologies. All cases were managed with Nanocrystalline-dressing "Acticoat" at Military Hospital Ambala. Study period was from Jun 2019 till Sep 2020.

160 pediatric patients reported with tissue defect wounds. Out of them, parents of 20 pediatric patients including those who refused surgical procedure participated in the study. All parents were explained about all modalities of treatment and their advantages and disadvantages. Parent of these patients choose nanocrystalline-dressing as their choice.

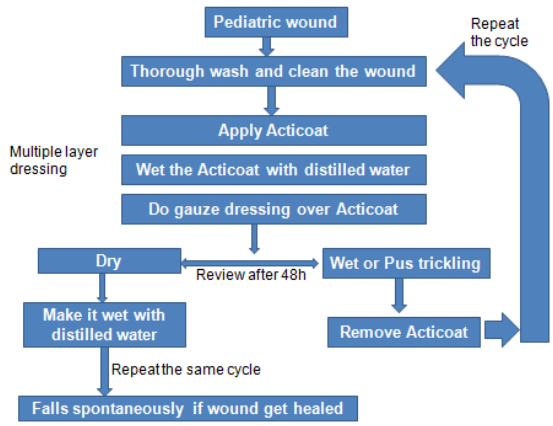

Figure 1. Treatment Protocol.

Acticoat dressing was applied after thorough wash of the wound and cleaning. Multilayer-gauze-dressing was done over the Acticoat. Patients were followed up in surgical OPD after 48h (every third day e.g. 3, 6, 9…). During the follow up visit, wound was inspected from the side for local-signs of inflammation like induration, Erythema, purulent discharge and offensive odor. If dressing was soaked and pus was seen trickling, acticoat was removed. Pus swab was taken for culture and sensitivity. It was again reapplied after thorough washing and cleaning. If it was dry, few drops of distilled water were poured

over the Acticoat to wet and gauze dressing was done to cover the wet Acticoat (**Figure 1**). The Acticoat fell spontaneously if wound got healed or changed after 07 days. For burn blisters, we aspirated the fluid, removed epidermis and applied the acticoat. Uncontrolled local infection, Signs of systemic-infection, Non-migration of epithelial cells or non-contraction of wound-margin were taken as treatment failure. Satisfactory level of patient was recorded from each parent after completion of treatment. Parents gave score out of 10.

Informed and written consent were taken from each and every parent whose son or daughter got treated with Acticoat and participated in the study.

Permission from local ethical committee was not taken as the study was a case series analysis. Acticoat has also been a widely accepted treatment modality for various wound like burn, infective wound etc. The clinical-photographs were acquired after the consent of parents.

RESULT:

20-pediatric-patients were treated at this centre with Nanocrystalline-silver-dressing (Acticoat). Summaries of all-20-patients were given in **Table 1**. Out of these 17-patients were infants. 0ut of 17-infants, 08 were neonates (**Table 1**). Major causes of wounds were Burn, trauma, infections and iatrogenic injury (extravasations of dextrose and tissue necrosis following noradrenalin) (**Table 1**). **Mean-sessions** of acticoat dressing and **Mean-days** of treatment are **3.1** and **17.6 days** respectively (**Table 1**). **9-cases** out of 20 were **burn-cases** with **mean-sessions of dressing** and **mean-days of treatment** were **02** and **12.11 days** (**Table 1**). **Mean-satisfactory-Score** of parents was **9.15** (out of 10) **(Table 1).** We found not **a single case of treatment failure** and **not single case local** as well as **systemic toxic effect** (**Figure 2-4**).

Table.1 Summary of 20 participants

Serial No.	Age of patient	Gender	Diagnosis	Wound size	No. of acticoat dressing / Days of treatment (n/days)	Satisfactory score of parents (n/10)
1	07 days	M	Tissue necrosis Right foot after iatrogenic extravasations of 10 % dextrose	(4 X 4) cm	6/28	10/10
2	24 days	F	Tissue necrosis Lt foot after iatrogenic extravasations of 10% dextrose	(3 X 2) cm	3/21	9/10
3	26 days	F	Cellulites following unknown bite	(4 X 3) cm	5/21	8/10
4	26 days	M	Scald Burn both Upper Limb	(8 X 9) cm	2/14	9/10
5	3 months	M	Scald Burn Chest and Abdomen	(6 X 10) cm	2/14	10/10
6	6 months	F	Friction burn both buttocks following RTA	(4 X 8) cm	3/18	9/10
7	17 months	M	Scald Burn chest and Left Upper Limb	(8 X 6) cm	2/14	10/10
8	18 days	F	Tissue loss following trauma	(2 X 3) cm	4/21	9/10
9	2 months	F	Flame burn back	(8 X 10) cm	2/10	9/10
10	2 year	M	Tissue loss following trauma	(3 X 3) cm	3/14	8/10
11	14 days	F	Tissue necrosis Right hand after iatrogenic extravasations of 10 % dextrose	(3 X 3) cm	4/26	9/10
12	6 months	M	Flame burn back	(10 X 12) cm	2/10	9/10
13	2 year	M	NSTI Left leg (Optd)	(4 X 4) cm	4/18	8/10
14	08 months	F	Non-healing ulcer Left leg	(4 X 4) cm	5/36	9/10
15	2 months	M	Flame burn chest and Abdomen	(14 X 12) cm	2/12	10/10
16	3 months	F	Cellulitis Right leg	(3 X 4) cm	4/22	10/10
17	04 month	M	Tissue loss Right forearm following trauma	(2 X 3) cm	3/18	9/10
18	18 days	M	Scald Burn Back	(4 X 4) cm	2/10	10/10
19	11 months	M	Flame Burn Right Upper Limb	(4 X 6) cm	2/12	9/10
20	27 days	M	Scald Burn back	10 X 11 cm	2/13	9/10
Mean (a. Sessions of Acticoat dressing / days of treatment b. satisfactory score)					**(a) 3.1/17.6**	(b) **9.15/10**

DISCUSSION:

Burn, trauma, infections and iatrogenic injury (extravasations of dextrose) were the major causes of the wounds in our case series (**Table 1**). Three patients were diagnosed as neonatal hypoglycemia and were managed with intravenous 10% Dextrose infusion. It was extravasated and caused tissue necrosis. The tissue-defect wound was comparatively huge as compared to their body surface area. It was initially planned for SSG with graft harvested from mother. However, parents refused the procedure and asked for non-invasive procedure or dressing.

After discussing all possible non-operative treatment modalities, they chose nanocrystalline-silver-dressing. All parents demanded an effective, relatively pain-free dressing which required to be changed less-frequently and to be managed as outpatient.

Finding an ideal and the most effective treatment was a herculean task. Treatment using TIME principle (tissue, infection / inflammation, moisture balance, edge of wound) —[5,6] and Negative pressure wound therapy –[7] were a good modality for treatment with moderate tissue defect. However, Pediatric age group did not cooperate to such modality and parents were unwilling.

The ideal wound dressing should be cost effective, comfortable and causing minimum pain, able to maintain a moist environment, able to promote healing and enable gaseous exchange, able to protect from secondary infection, easy to handle and enable removal without causing trauma, able to allow ongoing assessment and to result minimal scarring[1].

The ideal silver containing dressing must be able to maintain a sustained, controlled therapeutic silver ion concentration (≥30 ppm) in the treating wound without causing any systemic or any local (≤60 ppm) silver toxicity for several days [8].

SSD has silver, glycols, alcohols, and sulfadiazine[9]. SSD is found to release an extremely high initial silver concentration into the wound (up to 3,176 ppm) –[10], which rapidly decreases to below therapeutic levels[8]. The initial peak silver concentration after SSD is almost **53 times** the required level of concentration. SSD can therefore have comparatively a higher local toxicity, without providing the sustained silver levels necessary for microbicidal activity [8]. Additionally, propylene glycol in SSD formulation, is well known to cause bone marrow toxicity and leucopenia —[11,12]. A per many published studies, SSD had poor outcome in burn patient in terms of infection, epithelialization –[13,14]. SSD has poor cosmetic outcome as compared to Acticoat. SSD can increase hypertrophic scar formation –[15].

Many studies showed that dressings containing nanocrystalline silver have been found to be superior to SSD and to silver-free dressings for burns, in terms of epithelialization, infection, pain, and cost ——————[12,1619]. In addition, dressings containing nanocrystalline silver significantly reduce the cost of care when compared to SSD [8]. Acticoat also enhances growth of granulation tissue [20]. **Hence, we chose acticoat over SSD for treatment of tissue-defect pediatric wound**.

Acticoat in addition to creating a moist-wound-healing environment, delivers a controlled, sustained, antimicrobial-dose of 50–100 mg/l of silver-ions to the wound for up to 48 h following application –[2]. On adding water or in 100% humidity, Acticoat continually releases Silver (Ag0 clusters and Ag+) over several days, meaning that the dressing does not require daily changing[21]. **Hence, we followed our patient for every third day (after 48h)** and **distilled water was poured over acticoat for humidity**.

Smith and Nephew et al also showed a two-fold benefit of moistening Acticoat in their study: it unleashes the antimicrobial power of

nanocrystalline silver and assists in maintaining a moist environment to promote wound healing[22].

There were three types of nanocrystalline wound products: **Acticoat™**, **Acticoat-7**, and **Acticoat Absorbent™** [23]. If re-moistened, Acticoat produces a controlled release of clusters of silver cations onto the wound, for up to **3 days (if using Acticoat™)** or **7 days (if using Acticoat-7)[23]**. Hence, we used Acticoat-7 in our case series to minimize the frequency of dressing. **Acticoat-7 thus enabled us to change once in a week**.

Burn, trauma, infections and iatrogenic injury (extravasations of dextrose) were the major causes of the wounds in our case series. Three patients were diagnosed as neonatal hypoglycemia and were managed with intravenous-10%-Dextrose-infusion. It was extravasated and caused tissue necrosis. The tissue-defect wound was comparatively huge as compared to their body surface area. It was initially planned for SSG with graft harvested from mother. However, parents refused the procedure and asked for non-invasive procedure or dressing.

Overall mean sessions of acticoat dressing and **overall mean days of treatment** are **3.1** and **17.6** days **(Table 1)**. **4** out 20 were treated as inpatient. 9 cases out of 20 were **burn cases** with **mean sessions** of dressing and **mean days of treatment** were **02** and **12.11 days.** This result is comparable to study by Leila Cuttle et al[21]. Acticoat treated group averagely took **14.9 (+/- 9.7)** days for complete re-epithelialization[21]. **Mean-satisfactory-Score** of parents in our study was **9.15** (out of 10)**.** We found **not a single case of treatment failure**.

The systemic toxic effects are due to silver absorption through the wound, leading to argyria[1], which manifests as irreversible gray skin discoloration and loss of night vision ———[2426]. Other Study by Yara et. al. showed that topical silver therapy had limited side effects and its uncommon silver toxicity such as argyrosis were generally resolved with cessation of the therapy [1].The local toxic effects of silver are due to the cytotoxicity of the silver-ion against keratinocytes and fibroblasts[8] which may manifest as delayed wound healing. **Not a single patient in our study reported with local or systemic toxic effect of silver.**

Take home message:

(a) Advantages:

These case series has good comparable result to other studies [21] (Table 1, Figure 2-4). Satisfactory score is excellent with 9.15 (out of 10). No treatment-failure, no systemic or local toxic-effects were observed.

(b) Disadvantages:

Our study was case series and had very small sample size and had not compared with other treatment modalities.

(c) Future Directions:

Neonates are very delicate age group from treatment point of view. In today's era, there is a paradigm shift in the direction of wound management from more invasive to more effective minimum invasive modalities without complications. More research is required in use nanocrystalline-silver (e.g. Acticoat) in neonates and infants. More comparative study of Nanocrystalline-silver-dressing to other treatment modalities including SSG may benefit all pediatric cases for tissue-defect wound other than burn.

2(a) Scald burn of left upper limb

2(b) Scald burn left upper limb and torso

2 (c) Flame burn with loss of epidermis

2 (d) Scald burn with fluid filled blisters

Figure 2. Some representative pictures of wounds on presentation at our centre

3 (a) Presentation at Day-01 at our centre

3(b) Result after 2 sessions of Acticoat: dorsal aspect, Picture taken on Day-28.

3(c) Result after 2 sessions of Acticoat: palmer aspect, Picture taken on Day-28.

Figure 3. 26-days-old neonate with scald burn both Upper Limb (Left>Right)

4 (a) Day-1 of Surgical referral

4 (b) After thorough wash and cleaning

4 (c) Result: Status after Day-28 and after 06-sessions of Acticoat-dressings

4 (d) Result: Status after 03 months

Figure 4. 07-days-old neonate with tissue defect wound following iatrogenic extravasations of 10% Dextrose.

CONCLUSION:

Acticoat is one of the best treatment options for tissue-defect-wound especially in pediatric-cases and those who are unfit for surgery. There is very little study in literature to assess effectivity of Acticoat in pediatric age-group patient. Satisfactory level of parents is very high with Acticoat as it can be managed as outpatient. Acticoat dressing was very effective, relatively pain-free and did not require frequent change of dressing. For better understanding of Acticoat in pediatric wound, further study with larger sample size and comparing with other methods of treatment are necessary.

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