Silver containing hydrofiber dressing promotes wound healing in paediatric patients with partial thickness burns

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Introduction: Burn injury is one of the most common reasons for admission in paediatric population. There is currently no international consensus on the best wound dressing material. Aquacel Ag, a new silver containing hydrofiber dressing material has been reported to produce good clinical results. Yet only a limited number of studies exist in the paediatric population. This study aims to review our experience of burn management over the past 5 years and to evaluate the effectiveness of Aquacel Ag in the management of partial thickness burns.

Methods: A retrospective review of all patients admitted for burn injury between January 2010 and December 2014 was conducted. Patients' demographics, mechanism of injury, body surface areas involved, treatment applied and clinical outcomes were analyzed. Patients with superficial injury, full thickness burns that required surgical debridement, burn area less than 2% or more than 25% of total body surface area, or incomplete clinical data were excluded from the comparative study.

Results: A total of 119 patients were identified. 114 (96%) was due to domestic injury, of which 108 (91%) was food related. The most commonly affected areas were limbs (n=89, 74.8%), followed by trunk (n=62, 74.8). 84 patients fulfilled the inclusion criteria and were recruited into the study. 31 patients received Aquacel Ag dressing and 53 patients received standard paraffin gauze dressing. The 2 groups showed no statistical difference in age, sex, percentage of total body surface area involved and infection rate. Outcomes of patients treated with Aquacel Ag were compared to patients treated with standard dressing. The mean hospital stay was significantly shorter for the Aquacel Ag group (14.26 vs 23.45, $p = 0.045$). Aquacel Ag group required much less frequent dressing change (5.67 vs 20.59, $p = 0.002$). 5 patients in standard dressing group developed hypertrophic scar and required prolonged pressure garment, whereas only one hypertrophic scar was observed in the Aquacel Ag group.

Conclusion: Aquacel Ag appears to promote early burn wound healing with less hypertrophic scar formation.

Introduction

Burn injuries are relatively common in children, with scalding being the leading mechanism among all the causes [1]. While the treatment protocol for first degree and full thickness burns are better established, the management algorithm for partial thickness burns, of which the majority of paediatric scald cases are, is not universally standardized. In different burn centres, various dressing materials and protocols are used [2].

An ideal burn dressing material should provide a well moisturized environment to prevent fluid loss, and at the same time has good absorptive ability to remove excessive exudate; it should act as a good bacterial barrier with minimal disturbance on tissue healing [3]. The frequency of dressing change and the pain associated are of particular importance in paediatric practice. Among all the dressing materials, Aquacel Ag (ConvaTec, Princeton, NJ, USA), has been shown in some in-vitro studies to possess many of the aforementioned qualities [4, 5]. This dressing is a non-woven sodium carboxymethylcellulose material containing 1.2% ionic silver. It has been proposed to be the dressing material of choice for partial thickness burns owing to its absorbent and antibacterial properties.

The efficacy of Aquacel Ag in treating partial thickness burns have been shown in mostly in several adult studies, with only a few comparative studies performed in children [6-11]. This study was, therefore, undertaken to review our experience with Aquacel Ag in paediatric partial thickness burns when compared to conventional standard dressing material.

Materials and methods

A retrospective study of all patients admitted for burn injury to our centre between January 2010 and December 2014 was performed. The study was conducted after being approved by the ethics committee. Medical records of patients were reviewed with data extracted. Patients' demographics including age, sex, mechanism of injury, body surface areas involved, degree of injury, treatment applied and clinical outcomes were subsequently analyzed. Exclusion criteria were superficial epidermal burns only, full thickness burns that required surgical debridement or skin grafting, burn area less than 2% or greater than 25% of total body surface area, delayed presentation to hospital more than 24 hours after the burn injury, or incomplete clinical data.

Burn patients admitted to our centre were managed with prompt clinical assessment by on call officers followed by standardized triage protocol. The injured area was temporarily covered with clean cling film while basic physiological parameters were taken. The body surface area involved was calculated according to the Lund and Browder chart with photos taken. The anatomical location, the distribution of involved area and the depth of injury were documented in detail. Appropriate analgesics and sedation were titrated before start of dressing procedure. Blisters were aspirated and wound swabs were taken for microbiological analysis. Wounds were then cleaned with betadine solution with debris removed. Conventional standard dressing of injured areas were covered with paraffin-based gauze followed by a layer of cover gauze and outer retention dressings. All these dressings were changed daily until epithelialization completed.

Aquacel Ag was first introduced to our unit in 2009 and gradually became the major dressing material used. It was changed only every 3 to 4 days for wound inspection. Patients in both the standard dressing group and the Aquacel Ag group were discharged from the hospital when intravenous analgesics were no longer required and simple dressing changes can be managed by caretakers at home easily. All burn patients were followed up in joint clinic together with occupational therapist for scar assessment and prescription of pressure garment.

Data of the two groups of patients were statistically compared and analysed using SPSS (version 17; SPSS, Chicago, IL). Continuous variables were studied using Student's t test, while ordinal variables used Mann–Whitney U test and categorical variables used Chi-square test respectively. Data were presented as mean ± standard error of mean and range. $p < 0.05$ was considered statistically significant.

Results

A total of 119 children were admitted between 2010 and 2014. 114 patients (96%) were victims of domestic accidents and 5 patients sustained their injury outdoor. The most commonly affected areas were limbs (n = 89, 74.8%), followed by trunk (n = 62, 52.1%), head and neck (n = 24, 20.2%) and perineum (n = 13, 10.9%). 35 patients were excluded from the study: 15 of them involved superficial epidermal burns only and 2 patients suffered from full thickness burns with subsequent surgical debridement; the other 18 patients were excluded as the involved burn surface area were less than 2% or due to incomplete clinical data.

84 partial thickness burn patients satisfied all the inclusion criteria. 31 patients received Aquacel Ag as dressing material and 53 patients received standard dressing. The two groups had comparable demographics with no statistical difference (Table 1).

The mean hospital stay was significantly shorter for the Aquacel Ag group (14.26 ± 1.90 vs 23.45 ± 3.26 days, $p = 0.045$). On average patient dressed with Aquacel Ag received 5.67 ± 0.77 dressing changes during the hospital stay, however the frequency was much higher for standard dressing group patients (20.59 ± 2.93, $p = 0.002$). Wound swab culture was positive in around half of the patients in both groups ($p = 1.0$). There was no statistical difference in the risk to develop hypertrophic scar which required prolonged pressure garment or surgical excision in the two groups (one patient in Aquacel Ag group and 5 patients in standard dressing group, $p = 0.41$). The outcome measures were summarized in table 2.

Cost analysis was performed on a hypothetical case of 2 years old girl admitted for 6% partial thickness burns with respect to the 2 types of dressing materials used. The age of patient, percentage burn area, frequency of dressing changed and hospital stay were the average value generated from the 2 groups. $0.03m^2$ of skin involvement was used based on the assumptom of $0.5m^2$ of total body surface area in a 2 years old infant. The cost analysis revealed that despite Aquacel Ag is more expensive than standard dressing per unit size, due to the more frequent dressing required and longer hospital stay, the total cost is on average $4000 less. Table 3 summarized the total expenditure needed comparing the 2 dressing materials

Discussion

The choice of dressing material has long been recognized as the cornerstone in management of partial thickness burn. In the quest for the best dressing material, the hydrofiber properties of Aquacel made it an attractive option. It consists of sodium carboxymethylcellulose which has high fluid absorbency and can form a gel with wound exudates by vertical absorption [12]. The gel forming ability is crucial in making Aquacel atraumatic to healing wounds because it allows the dressing to adhere to wound surface without tissue growing into the dressing itself, thus protecting the delicate newly formed tissue. This also explains why it is associated with less pain during dressing procedure when compared to some conventional dressing materials [13].

Silver containing wound dressing has become popular in recent years owing to the increasing awareness of its antibacterial effect. Since the first report of silver nitrate application to burn wounds by Moyer et al. in 1965, the antibacterial mechanism of silver has been extensively investigated [14]. Elemental silver itself has no antimicrobial effect. However, in the ionic form, silver cation can interfere with bacterial cell wall structure, as well as to cause blockage of the respiratory cytochrome transport system [15]. Ionic silver can also bind to bacterial DNA to inhibit its replication and cell division. Due to the multiple mechanisms involved, ionic silver exhibits bactericidal effect against a wide range of bacteria including Gram-positive, Gram-negative, aerobic and anaerobic bacteria. Bacterial resistance to silver is rarely reported due to the same reason [16].

The concept of Aquacel Ag is to combine the ideal physical properties of hydrofiber together with the antibacterial effect of silver. In contrast to the conventional form of medicinal silver, such as silver nitrate solution or silver sulfadiazine cream, Aquacel Ag allows a more gradual and prolonged release of silver to the burn wound. This is because silver ion is released from the carboxymethylcellulose fiber when it is hydrated. The controlled release of ionic silver ensures a sustained level of the active ingredient for its antibacterial action. As a result a moist and bactericidal interface is formed to act as a barrier against further infection, which at the same time absorb excessive fibrous exudate. The wound adhering ability and thus less dressing changes made this material particularly suitable for paediatric patients in whom the dressing procedure can be stressful to both patients and parents.

Currently there were only few clinical studies reported in the literature concerning the application of Aquacel Ag to paediatric patients with partial thickness burns [6-8, 17, 18]. In our study the hospital length of stay was significantly shorter for the Aquacel Ag group, which was in line with the findings previously reported, despite different control group material was used (paraffin gauze standard dressing used in our study). The dressing frequency was also significantly less in the Aquacel Ag group, which was 3 to 4 times more frequent in the standard dressing group. Indeed the number of dressing change required for Aquacel Ag may still be an overestimate because we remove the dressing for inspection every 3 to 4 days when we were less experienced with this relatively new dressing material, as opposed to the duration of up to 2 weeks suggested by the product manufacturer. The dressing frequency would certainly drop by a significant proportion if we allow the dressing to be left in place until it falls off naturally as in other study [7]. Previous in-vivo model demonstrated a significantly lower bacterial load in Aquacel Ag treated group than the non-silver containing group [19]. Interestingly the bacterial burden was comparable between the 2 groups in our study. Nonetheless the beneficial effects of Aquacel Ag still translates into superior clinical outcomes in terms of faster recovery and less hypertrophic scar formation, despite the later did not reach statistical significance. It may be due to the anti-inflammatory and wound healing enhancement effect exerted by silver [20, 21]. No major adverse reaction was seen throughout the study period. Caruso et al. had warned against the potential in decreased mobility when the dressing was applied over joint space for prolonged duration [9]. This was not seen in our patients as we cut the Aquacel Ag into smaller pieces before it was applied over joint areas followed by regular physiotherapy. Other previously reported minor complications including local wound burning or dressing slippage were not noticed in our study.

We acknowledge there were several limitations in the current study. The weakness of retrospective study design was obvious. Patients in the study were not randomized nor blinded to the treatment made the results vulnerable to selection bias. In addition, pain score was not recorded throughout the study period so there was no information on patients' quality of life. The small sample size also limited the generalizability of the study results.

In conclusion, the use of Aquacel Ag in paediatric patients with partial thickness burn is safe and required less dressing changes. It shortens hospitalization and can reduce overall cost. Prospective study with larger number of patients is necessary to determine its true significance and impact on patients' quality of life.

Disclosures

The authors have no conflicts of interest to declare.

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Table 1 - Patient demographics

	Aquacel Ag	**Standard dressing**	***p***
Numbers	31	53	
Mean age (year)	2.38 ± 0.31 (0.17-9)	3.81 ± 0.59 (0.17-17)	NS
Sex: male (no.)	17 (55%)	28 (53%)	NS
Body surface area involved (%)	5.65 ± 0.58 (2-15)	6.24 ± 0.65 (2-25)	NS
Mechanism of injury (no.)			
Scald	30 (96%)	51 (96%)	
Flame	1 (4%)	1 (2%)	
Contact	0	1 (2%)	

NS indicates not significant.

Table 2 – Post-injury outcomes

	Aquacel Ag	**Standard dressing**	***p***
Mean duration of hospitalization (day)	14.26 ± 1.90 (4-51)	23.45 ± 3.26 (4-125)	0.045
Mean frequency of dressing changes (times)	5.67 ± 0.77 (1-24)	20.59 ± 2.93 (3-110)	0.002
Positive wound swab culture (%)	48.4	49.0	NS
Staphylococcus aureus (no.)	5	11	
Coagulase negative Staphylococcus (no.)	6	7	
Pseudomonas aeruginosa (no.)	2	1	
Others (no.)	2	7	
Hypertrophic scar (no.)	1	5	NS

NS indicates not significant.

Table 3 – Cost comparison for a 2 years old patient with 6% (0.03 m^2) partial thickness burn

	Aquacel Ag	**Standard dressing**
Cost of dressing material per change ($)	7 x 3 = 21	0.2 x 3 = 0.6
Cost of dressing material per 0.01 m^2 ($)	7	0.2
Other cost of each dressing change ($)	30 + 5 = 35	30 + 5 = 35
Nursing cost ($)	30	30
Dressing set and antiseptics ($)	5	5
Cost of each dressing ($)	21 + 35 = 55	0.6 + 35 = 35.6
Number of dressing changes	6	20
Cost of dressing ($)	**6 x 55 = 330**	**20 x 35.6 = 712**
Duration of hospitalization (day)	14	23
Cost of hospital stay per day ($)	400	400
Cost of hospitalization ($)	**14 x 400 = 5600**	**23 x 400 = 9200**
Total expenditure ($)	**330 + 5600 = 5930**	**712 + 9200 = 9912**

All costs given in US dollars.