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Evaluation of Scarring in Pediatrics Burns

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Objective: Post-burn hypertrophic scar occurs in between 30 - 90 % of burn patients and its most common risk factor is prolonged inflammation at the wound site. In the present study, we aimed to evaluate the healing time of scarring in Mongolian pediatric patients. **Methods:** We performed a prospective study of 20 pediatrics burns treated operatively and non-operatively at the National Burn Center in Ulaanbaatar from 2017 to April 2019. Scar assessment was performed by a senior burn therapist using the POSAS evaluation. **Results:** Overall rates of hypertrophic scarring were 28.2 %. Time to healing was the strongest predictor of developing hypertrophic scarring, and the earliest hypertrophic scar developed in a patient who healed after 8 days. The risk of hypertrophic scarring was multiplied by 1.13 for every additional day taken for the burn wound to heal. **Conclusions:** The risk of hypertrophic scarring increases with every day and, therefore, every effort should be made to get the wound healed as quickly as possible, even within the traditional 3-week period usually allowed for healing.

Keywords: Scar, Hypertrophic, Burn, Healing Time, Pediatrics, Cicatrices, Connective Tissue

Introduction

A hypertrophic scar is a thickened, wide, often raised scar that develops after injuries such as burn, laceration, abrasions, surgery, and trauma. It is considered to be a dermal form of fibroproliferative disorders that are caused by aberrant wound healing. A hypertrophic scar is red, raised, rigid, and can cause pruritus, pain, and joint contracture. Moreover, formed in the facial area, the hypertrophic scar can cause cosmetic disfigurement, which results in psychological and social issues. Post-burn hypertrophic scar occurs in between 30 – 90 % of burn patients and its greatest risk factor is the prolonged inflammation at the wound site [1 - 3].

Studies indicated that there is neither a single agreed definition of HTS nor a single best method for assessing burn scars. However, there are at least five methods for scar assessment scales that were designed to assess subjective parameters objectively: Vancouver Scar Scale (VSS), Manchester Scale

(MSS), Patient and Observer Scar Assessment Scale (POSAS), Visual Analogue Scale (VAS), and Stony Brook Scar Evaluation Scale (SBSES). Each of these scales is with a scoring system and analyzing attributes, therefore it is difficult to compare studies to get an idea of the impact of hypertrophic scars in different groups of patients [4 - 5]. For example, POSAS consist of two six-item numeric scales reflecting the patient's perspective and the observer's perspective, on the other hand, VSS reflects the observer perspective only. Wallace et al conducted a prospective case-control study among 186 children who sustained a burn injury in Western Australia using a modified VSS. It has been shown that when the percentage of the total body surface of burn increased by 1 %, the odds of a raised scar increased by 15.8 % (95 % CI = 4.4–28.5 %). The raised scar was also predicted by time to healing of longer than 14 days (OR = 11.621; 95 % CI = 3.72 – 36.23) and multiple surgical procedures (OR = 11.521; 1.99 – 66.56) [6]. Another follow-up study demonstrated that days to re-epithelialization were a significant predictor of skin/scar quality at 3 and 6 months ($p < 0.010$). Patient-rated color and observer-rated vascularity and pigmentation POSAS scores were comparable at 3 months (color vs. vascularity 0.88, $p < 0.001$; color vs. pigmentation 0.64, $p < 0.001$), but patients scored higher than the observer at 6 months (color vs. vascularity 0.57, $p < 0.05$; color vs. pigmentation 0.15, $p = 0.60$). Burn depth was significantly correlated with skin thickness ($r = 0.51$, $p < 0.01$) [6, 7].

Hypertrophic and keloid scars greatly affect the quality of life of the patient. Especially in younger age groups and female patients, hypertrophic and keloid scars are found more in multiple anatomical sites and tend to itch and hurt [8], therefore may require further surgical or non-surgical intervention. In the study of Deitch et al. it was demonstrated that, if the burn wound healed between 14 and 21 days than one-third of the anatomic sites became hypertrophic; if the burn wound healed after 21 days than 78 % of the burn sites developed hypertrophic scars [9]. The prospective study performed in 383 pediatric burns also revealed that time to healing was the strongest predictor of developing hypertrophic scarring, and the earliest hypertrophic scar developed in a patient who was healed after 8 days. The risk of hypertrophic scarring was multiplied by 1.138 for every additional day taken for the burn wound to heal. There was a trend towards higher rates of hypertrophic scarring in non-white skin types but this did not reach statistical significance [10]. In another study by Dedovic et al. the occurrence of hypertrophic scarring in burn-injured children was at least 32 %, however, the occurrence of hypertrophic scarring did not appear to have been influenced by changes in clinical practice [11].

By the results of the above-mentioned studies, one can be affirmed that it is quite difficult to compare the results because of the different denominators and sample sizes as well as heterogeneous patient populations. Moreover, a lack of consistent definitions of risk factors and valid scar outcome classification also could be the reason for these difficulties. Therefore, in this study, we aimed to evaluate the healing time of pediatric scars in Mongolia. The present prospective study included 20 pediatric patients treated operatively and non-operatively at the National Burns Center in Ulaanbaatar 2017 to April 2019. Scar assessment was performed by a senior burn therapist using the POSAS.

Materials and Methods

Research design

We conducted a retrospective study of children treated within the National Burn Centre. A total of 20 patients participated. Among them 9 patients were evaluated as second degree and 11 patients were evaluated as third-degree burns. Each patient was treated and evaluated for scare condition. The evaluation was done repeatedly at 1st, 7th, 14th, 30th and 60th days. Inclusion criteria were patients aged less than 17 years, presenting with acute burn injuries. Those who failed to complete their treatment and follow-up, or who were followed up elsewhere, were also excluded. Data were collected prospectively over a 2-year period from 2017 to April 2018. Data collected for each patient included age, size, and site of the burn injury. Each patient or parent was also asked about any first aid performed and history of previous hypertrophic scarring. Patients were followed prospectively, and progress of wound healing and any clinical signs of infection were assessed at each dressing change. Day of healing was recorded as the first attendance for review when the wound had completely healed and there was no further necessity for dressings. As outpatients were not reviewed daily, the first appointment at which the wound had completely healed was recorded as the actual day of wound healing. Digital color photographs were taken of each burn site at the time of initial assessment and each dressing change until the wound had

healed. An experienced burn therapist assessed scarring using the modified POSAS Scar Scale [7, 8]. Where a patient had more than one POSAS recorded during their follow-up, the highest value was used.

Statistical analysis

Continuous variables were summarized as means and categorical variables as counts and percentages. Independent t-test was carried out for mean values between two groups. For categorical variables, Fisher's exact tests were used. The main effects of time, degrees of a scare, and their interaction were determined using a mixed two-way ANOVA with a Greenhouse-Geiser adjustment for lack of sphericity. A critical p-value of < 0.05 was used. The repeated measurements within subjects were then compared to the previous time interval using the paired t-tests. SPSS version 25 software (SPSS Inc., Chicago, IL, USA) was used for statistical analyses.

Ethical statement

The study was approved by the Research Ethics Committee of the Mongolian National University of Medical Sciences (No.2021/3-07). All patients provided written informed consent before participating in this study.

Results

A total of twenty patients had complete sets of data available for analysis. Patients were divided into groups according to burn degree. The mean age was 5.68 ± 4.07 years (range 0.6 months to 17 years). The sites of the burn injuries were typical of the hand (Table 1) in this mostly pre-school age group.

In Table 2, we have shown the observer scar assessment scale. There were significant differences in POSAS scores between burn degrees at 30th and 60th days. In the group of second-degree burns, compared with baseline POSAS score (49.00 ± 4.98), the hypertrophic scar was below to score 3 after 1-2 months (3.33 ± 3.16 and 2.67 ± 3.16). On the other hand, in the group of third-degree burns, POSAS scores after 1-2 months were 6 ± 00.

In Table 3, the patient scar assessment scale is shown. Compared with the observer scale, only the 30th day POSAS score was significantly different between both groups. In the

Table 1. General characteristics of study participants by burn degree.

Variables	Burn Degree			p-value
	Second (n = 9) Mean ± SD	Third (n = 11) Mean ± SD	Total (n = 20) Mean ± SD	
Age, year	5.73 ± 5.31	5.64 ± 2.98	5.68 ± 4.07	0.962
	N (%)	N (%)	N (%)	
Gender				
Male	7 (77.8)	6 (54.5)	13 (65.0)	0.374
Female	2 (22.2)	5 (45.5)	7 (35.0)	
Cause				
Hot water	4 (44.4)	5 (45.5)	9 (45.0)	0.843
Other	5 (55.6)	6 (54.5)	11 (55.0)	
Location				
Hand	5 (55.6)	6 (54.5)	11 (55.0)	0.742
Other	4 (44.4)	5 (45.5)	9 (0.45)	
Healing				
Surgery	5 (55.5)	9 (81.8)	14 (70.0)	0.336
Bandage	4 (44.5)	2 (18.2)	6 (30.)	
Treatment				
Yes	1 (11.1)	6 (54.5)	7 (35.0)	0.050
No	8 (88.9)	5 (45.5)	13 (65.0)	

Table 2. The POSAS scare scale by doctor's evaluation post-burn.

Variables	Burn Degrees			p-value*
	Second [a] (n = 9) Mean ± SD	Third [b] (n = 11) Mean ± SD	Total (n = 20) Mean ± SD	
1st day	49.00 ± 4.98	48.18 ± 7.08	48.35 ± 6.07	0.891
7th day	6.11 ± 0.33	7.18 ± 2.75	6.7 ± 2.07	0.228
14th day	5.33 ± 2.00	6.45 ± 1.51	5.95 ± 1.79	0.185
30th day	3.33 ± 3.16	6.00 ± 0.00	4.8 ± 2.46	0.035
60th day	2.67 ± 3.16	6.00 ± 0.00	4.5 ± 2.67	0.013

Two-way mixed ANOVA results: Interaction of time and treatment F (1.167, 236.47) = 14.154, p < 0.002; Main effect of time F (1.319, 367.31) = 312.34, p < 0.032; Main effect of treatment F (1,171) = 0.621, p = 0.143; *Independent t-test second vs. third; Paired t-test: [a]day30th vs. 60th, p = 0.031; [b]day30th vs. 60st, p = 0.001.

Table 3. The POSAS scare scale by patient's evaluation post-burn.

Variables	Burn Degrees			p-value*
	Second [a] (n = 9) Mean ± SD	Third [b] (n = 11) Mean ± SD	Total (n = 20) Mean ± SD	
1st day	52.67 ± 8.73	50.00 ± 9.83	51.2 ± 9.21	0.529
7th day	14.56 ± 1.33	14.64 ± 0.67	14.60 ± 0.99	0.871
14th day	5.33 ± 2.00	6.00 ± 0.00	5.70 ± 1.34	0.346
30th day	3.33 ± 3.16	6.00 ± 0.00	4.80 ± 2.46	0.035
60th day	2.56 ± 3.05	5.64 ± 0.50	4.25 ± 2.55	0.162

Two-way mixed ANOVA results: Interaction of time and treatment F (1.816, 321.36) = 17.251, p < 0.051; Main effect of time F (1.462, 412.13) = 373.25, p < 0.041; Main effect of treatment F (1,843) = 0.092, p = 0.561; *Independent t-test second vs. third; Paired t-test: [a]day30th vs. 60th, p = 0.021; [b]day30th vs. 60st, p = 0.004.

Table 4. The Vancouver scare scale between age groups.

Scare conditions	Age Group			p-value
	< 5 years (n = 9) Mean ± SD	> 5 years (n = 11) Mean ± SD	Total (n = 20) Mean ± SD	
Blood supply	1.33 ± 1.12	1.09 ± 1.14	1.21 ± 1.11	0.639
Pigmentation	1.78 ± 0.44	2.0 ± 0.13	1.91 ± 0.31	0.169
Elastic	5.00 ± 0.12	4.12 ± 0.45	5.01 ± 0.32	0.258
Thickness	2.87 ± 0.44	2.91 ± 0.54	2.85 ± 0.48	0.158

second-degree burn group, the baseline score was 52.67 ± 8.73, while it was decreased to 3.33 ± 3.16 after the 30th day. On the other hand, in the third-degree burn group, the same evaluation was 6.00 ± 0.00, compared with the baseline score (50.00 ± 9.83). As discerned in table 4, there was no statistically significant difference between age groups.

Discussion

Burn is one of the high-frequency accidents in the world, caused by electricity, flame as well as chemical agents. Especially, according to the World Health Organization, thermal burns account for an estimated 6.6 million injuries and 300,000 deaths

each year worldwide [12]. Numerous studies demonstrated that a fourth of all burn injuries occur in children under the age of 16, and burn injury in children is a major epidemiologic problem around the globe [13 - 14]. In Mongolia, reported by The National Trauma and Orthopedic National Center, 62.2 % of ambulatory patients with burn injury in the Trauma Ward were children under 5 years old [15].

Acute burns can have a significant effect on the skin, and other organ systems. Particularly, the skin surface is severely destroyed in case of acute burns. In addition, infection may develop on damaged skin [16 - 18]. Scars following burn injury can greatly impact patients' quality of life related to appearance, pain, pruritus, and even loss of function of the injured body region. Moreover, burn scars can cause significant morbidity in terms of discomfort, pain, itching, especially for children, and also repeated trips for scar therapy can affect family and school life [19 - 21]. Keloids and hypertrophic scars are fibrous tissue outgrowths resulting from a derailment in the normal wound-healing process. However, there is not a formal definition of hypertrophic scars as determined by a red and raised scar that does not extend outside the boundaries of the original injury. As demonstrated by Lawrence et al. the prevalence rate varied between 32 and 72 %, and identified risk factors included dark skin, female gender, young age, burn site on the neck and upper limb, multiple surgical procedures, meshed skin graph, time to healing, and burn severity [22]. Another study conducted by Gangemi et al. also showed that among pathologic scarring diagnosed in 540 patients, 44 % had hypertrophic scars, 5 % had contractures, 28 % had hypertrophic-contracted scars. Moreover, based on the multivariate regression model, female sex, young age, burn sites on the neck and/or upper limbs, multiple surgical procedures, and meshed skin grafts were independent risk factors for postburn pathologic scarring [23].

There are several studies reported that hypertrophic burn scars are more common in non-white patient populations. Soltani et al. demonstrated that ethnicity alone was found to be an independent predictor of hypertrophic scar formation. Caucasian patients had the lowest rate of scar formation (11.8 %), while it was 32.2 % in Hispanic patients and 36.3 % for Asian patients [24]. Research of genetic risk factors for hypertrophic scar revealed that its formation was associated with American Indian / Alaskan Native race (OR, 12.2; $p = 0.02$), facial burns (OR, 9.4; $p = 0.04$), and burn size ≥ 20 % TBSA (OR, 1.99; $p = 0.03$) [22].

The prevalence of hypertrophic scarring after burn injury in children varies from 32 to 65 % [9, 11]. However, due to different denominators and sample sizes, heterogeneous patient populations, a lack of consistent definitions of risk factors, and a lack of consistent and valid scar outcome classification, there is difficulty comparing results between existing studies. Previous research of Cubison et al. showed that, among 337 children with scalds, overall hypertrophic scar rate was found to be: under 10 days to healing = 0 %, 10 - 14 days = 8 %, 15 - 21 days = 20 %, 22 - 25 days = 40 %, 26 - 30 days = 68 % and over 30 days = 92 %. If skin grafting is undertaken there is a much higher incidence of hypertrophic scar in the 10 - 14 days group: 10 - 14 days = 33 %, 15 - 21 days = 19 %, 22 - 25 days = 54 %, 26 - 30 days = 64 % and over 30 days = 88 % [1]. Another study by Karlsson et al. also demonstrated that, of the 58 children, fifteen children were assessed as having hypertrophic scarring, all of whom had healing times that had extended beyond 14 days. There were no differences in POSAS, VSS total scores, or incidence of hypertrophic scarring between the different dressings [23]. In the study by Kant et al. combined triamcinolone and verapamil treatment in keloid and hypertrophic scars resulted in significant improvement in hypertrophic scars. Overall POSAS scores revealed statistically significant decreases between baseline and 3 - 4 months, 4 - 6 months, and > 12 months after the start of therapy in both keloids and hypertrophic scars [24]. In the study of scar outcome of children with partial-thickness burns with 3 and 6 months follow up, it was demonstrated that patient-rated color and observer-rated vascularity and pigmentation POSAS scores were comparable at 3 months, but patients scored higher than the observer at 6 months. Burn depth was significantly correlated with skin thickness ($r = 0.51$, $p < 0.01$) [7]. Our study was consistent with this result, where overall POSAS scores were significant at the 30th day between the second and third-degree burn group. In detail, the baseline score was 52.67 ± 8.73, while it decreased to 3.33 ± 3.16 after the 30th day.

Our study has several limitations. To our knowledge, this is the first prospective study of pediatric burns in Mongolia with an examination of the healing time as well as hypertrophic scarring development, however, we did not have sufficient case numbers in this study. Another limitation is that our study did not include risk factors for developing hypertrophic scarring. Thus, in the future, further investigation is needed to examine the risk factors

in more detail, especially to determine the exact impact of skin type and site of injury.

Conclusion

The risk of hypertrophic scarring increases with every day and, therefore, every effort should be made to get the wound healed as quickly as possible, even within the traditional 3-week period usually allowed for healing.

Conflict of Interest

The authors declare that they have no conflict of interest concerning this study.

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