Management of Acute Hand Burns

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Abstract: Hands are the most commonly involved body part in burns. In greater than 90% cases, the burns are severe and carry with them a significant risk of morbidity even though the mortality associated is relatively less. Hand burns present challenges to the treating surgeon on many fronts. One is the assessment of severity and depth of the injury itself, where, clinical examination remains the gold standard. The other is the choice and performance of the most appropriate surgical procedure to provide optimal outcomes in terms of function and aesthetics. The one challenge with most impact is probably that of post-operative care and rehabilitation to preserve function at a level where the patient can carry on with activities of daily living at the least. The need for reconstructive surgery also arises at a later date to address issues like post-burn contractures and unstable scars. In this review, we present the approach to management of hand burns in the acute setting with consideration to both conservative and surgical modalities.

Keywords: Hand burns, Laser Doppler imaging, Fasciotomy, Splinting, Allografts.

1. INTRODUCTION

The hand occupies approximately three percentage of the body surface area. The functional consequences of hand burns are so significant that any burn injury of the hand beyond the first degree is considered severe and necessitates referral to a specialized centre for management [1]. The hands are also the most commonly involved part in burns and are involved in more than 80% of all burn injuries [2]. Adequate resuscitation and meticulous wound care are essential in the management of these patients. Surgical procedures in the burned hand are important to achieve good functional outcomes, more so when performed at the right time [3]. Long-term functional outcomes in this patient population can only be achieved when a team approach is utilized from the initial presentation to long-term follow up.

2. DISCUSSION

Hand burns may occur in an isolated fashion or may be a part of larger burn injuries. They are a leading cause of impairment after burn injuries [1].

The aims of management of hand burns were outlined in the landmark paper by Robson *et al*. [4] wherein they described five main points (Table **1**). These included Prevention of additional or deeper injuries, Rapid wound closure, Preservation of active and passive motion, Prevention of infection or loss of functional structures and early functional rehabilitation.

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2.1. Principles

For screening and better diagnosis of burn patients, it is necessary to take into account the extent and depth of the lesion. These parameters are intended to guide clinical management and subsequent surgical procedures. The important risk factors such as edema, inflammation and limiting movements that accompany thermal burn need to be carefully supervised. Therapeutic options consist of daily dressings with antibacterial agents, occlusive dressings in functional position, limb elevation and daily physiotherapy. Emergency procedures such as escharotomy, fasciotomy and carpal tunnel release, need to be considered when indicated. Not all hand burns require surgical treatment. However, the recognition of appropriate and timely surgical inter-

Table 1: Robson's Aims and Principles of Hand Burns

Aims
• Prevention of additional or deeper injuries
• Rapid wound closure
• Preservation of active and passive motion
• Prevention of infection or loss of functional structures.
• Early functional rehabilitation
Principles
• Determination of dimension and depth of the burn
• Escharotomy (if indicated)
• Application of adequate wound dressings
• Decision upon conservative or surgical treatment
• Surgical management (necrosectomy, skin grafts, skin substitutes, free laps etc.)
• Early hand therapy with splinting
• Functional rehabilitation by early active and passive motion due to physiotherapy
• Secondary and tertiary corrections (if indicated)

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vention such as necrosectomy, skin grafts, skin substitutes, free flaps etc. is crucial to achieve good functional results. Secondary and tertiary corrections may be required for deformities of hand and burn contractures, which are common sequelae of burns [4].

The main sections outlined in this article regarding the management of hand burns are as follows:

1. Determination of dimension and depth of the burn.
2. Escharotomy.
3. Application of adequate wound dressings.
4. Management of Blebs and Edema.
5. Splinting and physiotherapy.
6. Surgical management.
7. Application of Allografts.

3. DETERMINATION OF BURN DEPTH

The accuracy of dept assessment when carried out clinically by an experienced burns surgeon stands between 60-75% [4]. This however, still remains the gold standard for assessment of burn depth. The use of perfusion imaging techniques is adjunctive to clinical assessment. These include modalities like thermography, laser doppler techniques, video angiography and microscopy, and the use of vital dyes.

Monstrey *et al*. [5] proposed and validated a color code to assess the burn depth and consequently, the time to recovery from and burns, by looking at Laser doppler imaging (LDI) (Figure **1**). They were able to predict with reasonable accuracy, the healing time, and categorized the injuries (<14 days- red/pink, 14-21 days- yellow/green and >21 days- blue). They achieved a technical accuracy of 96% and clinical accuracy rates of greater than 90%. They also found that no other parameter influenced the healing time in their series.

Schiller *et al*. [6] classified patients into two categories according to percentage and volume of flow of doppler shifted light. They concluded that those with flow rates in the high group (150mv) were more likely to heal without requirement for a graft and those with low flow rates (89mv) needed a skin graft. They however also noted that the LDI values did not predict healing times taken. They retrospectively found that values did correlate with functional and cosmetic outcomes irrespective of the need for grafting or the time taken to heal.

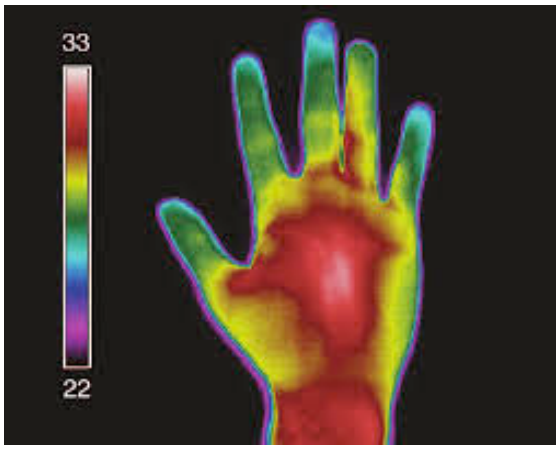

Figure 1: Laser Doppler Imaging of hand burns.

4. ESCHAROTOMY

It is critical to ensure that hand perfusion is adequate because this is an area in which early surgical intervention can make a tremendous difference in the ultimate outcome. This requires that the hand be re-examined with great frequency during the entire resuscitation period. Vascular compromise results when subcutaneous tissues become increasingly edematous beneath non-elastic eschar. When assessing the adequacy of peripheral perfusion, it is important to look at signs more subtle than the loss of detectable pulsatile flow in named arteries at the wrist. Mean arterial pressure in the central system is three times higher than distal capillary pressure, and blood flow may be maintained in these large vessels when flow in distal soft tissues is impaired. If the hand is warm and soft and has pulsatile flow detectable by Doppler in the palmar arch and digital vessels, then flow is adequate. As flow is progressively impaired, the hand will become firm and cool and Doppler flow will no longer be detectable in the palmar arch and digital vessels. Voluntary motion will become difficult, and the hand will assume a clawed position. At this point, escharotomies should be performed to prevent otherwise avoidable ischemic injury.

The maintenance of perfusion is the first and foremost aim in the acute treatment of hand burns. The presence of a nearly circular or circular deeper burn and an increasing edema should be an indicator for immediate escharotomy. Missing pulse of the radial or ulnar artery under adequate resuscitation is a sign of a progressed ischemia and requires immediate escharotomy. Patients who sustain extensive burn injuries require large volumes of intravenous fluid and will develop significant soft edema require prophylactic faciotomies.

A full release of the forearm may be achieved using either electrocautery or a scalpel to incise the eschar through two longitudinal incisions, radially and ulnarly, to the level of the 1st and 5th metacarpophalangeal joints. Decompress the carpal tunnel (Figure **2**). Decompression of the hand itself is achieved through longitudinal incisions between the metacarpals from the base of the hand to the head of the metacarpal taking care not to expose any tendons.

4.1. Finger decompression

The line of incision is radial on thumb and little finger and ulnar on the other fingers. This places the incision on the side of the digit with perhaps the least functional importance should the digital nerve be exposed by separation of edematous tissue after escharotomy. The central digital incisions can be extended proximally onto the dorsum of the hand between the metacarpals to enhance decompression.

Deep hand burns and in case of an intrinsic tightness, the intrinsic compartment should always be decompressed. Area between the metacarpals II/III and IV/V is incised longitudinally whereby the extensor tendons remain covered. From there a fasciotomy of the intrinsic compartments can be carried out [7-9].

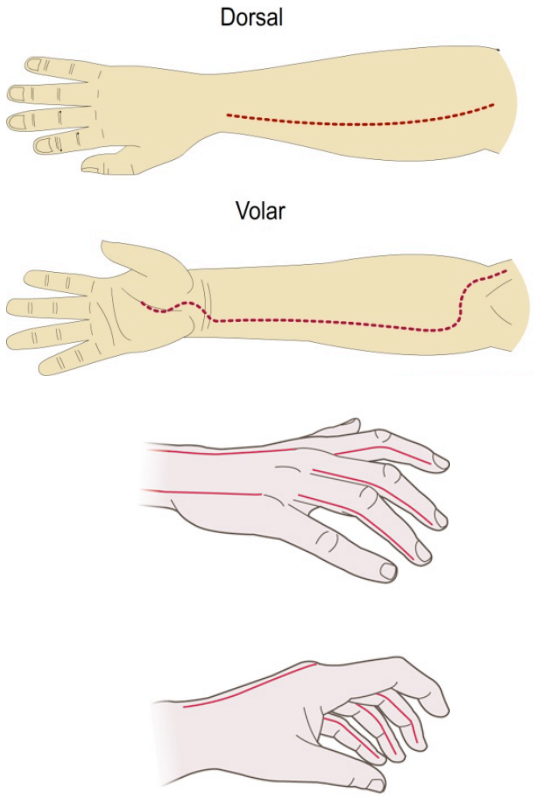

Figure 2: Faciotomy incision for forearm and hand.

5. WOUND DRESSING

Burned hands should be cleansed twice daily with a mixture of water and chlorhexidinegluconate. Burns that are clearly partial thickness may be managed with one-percent silver sulfadiazine cream. Indeterminate burns are placed in alternating agents, which include mafenide acetate 11-percent cream during the day and 1-percent silver sulfadiazine cream at night. Burns that are obviously full thickness or potentially infected are treated with twice-daily mafenide acetate [10].

5.1. Management of Blebs

Until some years ago, blisters were not removed because it was believed that they serve as a biological wound dressing. Recent studies showed though that the blister's secretion contains prostaglandins and other pro-inflammatory cytokines as for example interleukine-6 and interleukine-8. It is recommended to remove the blisters or at least the fluids.

6. EDEMA MANAGEMENT

The hand should be elevated above heart level as much as possible. It is also critical to extend the elbow sufficiently to promote venous drainage. Active exercise to activate the muscle pump decreases edema. Frequent episodes of active composite finger flexion and extension can be encouraged safely in superficial partial-thickness hand burns. There is risk of extensor tendon damage with passive composite flexion in deeper hand burns. Repetitive finger abduction and adduction requires contraction of the dorsal and palmar interosseous muscles, which assists in edema reduction and is generally indicated for burns of all depths [11,12].

In a study by Schrank *et al*. [13] compared Negative pressure wound dressing with standard edema control for hand burns. Results of study revealed a significant reduction or prophylaxis of the connective tissue edema. Better perfusion and wound healing. Extending the therapy applied to the hand to the entire extremity could contribute to avoiding operative stress (escharotomy) in selected cases. Troublesome supporting of the hands and the ergo-therapeutic use of splints were not necessary because of the exact fixation of the extremities ensured by the vacuum method (Figure **3**).

There have also been reports of successful usage of self adherent wraps in hand burns. During their 4-week study period, Lowell *et al*. [14] found that, there was less edema, greater active range of motion and grip strength, and greater dexterity in the hand with

3M™ Coban™ Self-Adherent Wraps as compared with the control hand.

Figure 3: Negative pressure wound therapy for hand burns.

7. SPLINTING

A splint has the distinct advantage of providing treatment beyond the sessions that the patient spends with the therapist. When used with pressure therapy, it can lead to minimization of disability by tackling contracted scars and making them supple. The treatment is often more effective when the patient actively participates in the splinting programme. The splint may be static or dynamic in nature, and depends on the viscoelastic properties of the involved tissues, scar maturation and mechanical principles. A good general guide is where the hand is slightly extended in the wrist with 20°–30°, flexed in the MCP joint with approximately 80° and completely extended in the IP joints (Figure **4**). The thumb is placed in maximum abduction. Different splints are used at different stages in rehabilitation [15,16].

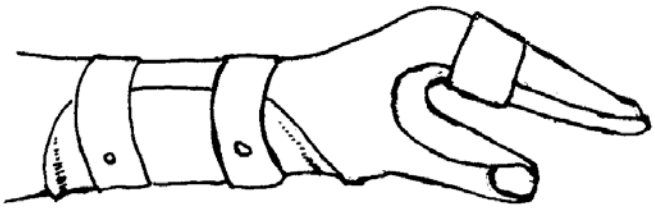

Figure 4: Burnt hand splinting position.

8. SURGICAL MANAGEMENT

There are many key issues to address in the surgical management of hand burns.

8.1. Spontaneous Healing vs Grafting

In a study by Sheridan *et al*. [17] in children with hand burns, normal functional results were seen in 97% of second-degree and 85% of third-degree injuries. Seventy percent ofChildren with burns involving underlying tendon and bone could perform activities of daily living and 20% had normal function. Reconstructive hand surgery was required in 4.4% of second-degree burns, 32% of third-degree burns, and 65% of those with injuries involving underlying bone and tendon. Edstrom *et al*. [18] concluded from their study of 222 patients of partial thickness burns of hand that spontaneous healing with waiting periods of up to five weeks provided results similar to excision and grafting at two weeks.

Frist *et al*. [19] in their study of 786 patients, similarly concluded that while non-operative management produced satisfactory results in superficial second degree burns, deeper second degree and third degree burns did well with early excision and grafting (93%, 95% an 93% for deep second degree, mixed second and third degree and third degree full-thickness hand burns respectively).

Goodwin *et al*. [20] agreed with the above studies on the fact that superficial burns responded similarly to both operative and conservative management, in their study of 164 burned hands. They went on to also conclude that earlier excision and grafting yielded poorer results that initial non-operative management and later reconstructive surgery in third degree burns.

Mohammadi *et al*. [21] in contrast to Goodwin *et al*. [20] findings, concluded that early excision and skin grafting gave better results in terms of shorter hospital stay in patients with deep second degree and third degree burns in their study of 40 patients. They however found that, with respect to function, scar formation, daily activity limitation and overall satisfaction, early excision and grafting and delayed grafting carried no significant difference.

Tambuscio *et al*. [22] studied 116 patients treated with escharotomy and skin graft. They found that when the graft was performed early (<4-6 days) from injury, the requirement of late revisions was significantly different from when the surgery was performed later (>14 days) (7.7%-early vs 36.8%-late).

8.2. Full Thickness Graft (FTG) vs Split Skin Graft (SSG)

In a study by Chandrasegaram hand burns was divided in to three groups A) hand grafts (palmar and/or dorsal grafts excluding digits); B) digit grafts; and C) hand and digit grafts (grafts to palm and/or dorsum including digits). In group A, the incidence of contractures with SSG was 26 vs 11% with FTG. Subgroup analysis revealed comparable contracture rates bet-

ween palmar and dorsal grafts treated with SSG, 24 vs 25%. The only FTG contracture was a palmar graft. The incidence of contractures in digit grafts or group B was low, 3 of 29 with SSG and 0 of 27 with FTG. In group C, the incidence of contractures in the SSG group was 43%, with none in the FTG group, (P=0.019). This was higher with SSG to the palm and digits at 67 vs 21% with dorsal grafts. The study revealed an overall 34 of 126 (27%) incidence of contractures with SSG and 1 of 45 (2%) with FTG. They recommended the use of FTG in the treatment of primary hand burns particularly where the burn involves the surface of the palm and extends into the digits [22]. In a study by Pensler *et al*. [24] comparing SSG vs FTG in palmar burns it was seen that there was no difference in the number of procedures or functional outcome in two groups. And advocated SSG for hand burns as it reduced operative time and morbidity.

8.3. Flaps

Flap cover in burns of the hand may be indicated in specific situations like exposed bones and tendons, unstable scars and post-contracture release. The use of local flaps often lead to sub-optimal results, possibly due to the involvement of the surrounding areas also in the burn injury. This is especially true in deep burns where a local flap may not be possible at all. Traditional abdominal and groin flaps are used, but carry disadvantages of being bulky and needing separation of digits. Modifications of the abdominal flap, like the glove flap or the Millard "crane" flap have to some extent produced better results in terms of both cosmesis and function [24-26].

Free flaps are rarely performed in burns of the extremity, but in rare cases, when performed early, may lead to early wound cover, mobilization, possible limb salvage and shorter hospitalizations. The traditional reluctance to carry out free flaps in extremity burn injuries, has been centered upon the concept that the area of damage is wider than what seems due to progressive tissue necrosis. This concept however, is under question. Advocates of early free tissue transfer in extremity burns cite studies that have shown greater flap survival when performed early. The use of the ALT flap for example in electrical burn injuries of the hand has shown excellent results for upper limb salvage [27-30].

9. ALLOGRAFT APPLICATION

Dantzer *et al*. [32] found a 100% take uptake of Integra® regeneration template when applied on deep dermal burns. Similar results were achieved by Cuadra *et al*. [33]. They included both patients with acute burns and those requiring reconstructive surgery. In these and other similar studies, the wounds were grafted with Integra® and a very thin split skin graft was applied after removal of the silicone layer once the neo-dermis had formed. They proposed that allograft usage reduced adherence of the graft to the deeper layers and permitted free articular movement while keeping the skin supple [31]. Matriderm® is a dermal substituent which has the added advantage of immediate epidermal grafting. In a study by Ryssel *et al*. [34] it was seen that Autograft survival was not altered by simultaneous application of the dermal matrix. Vancouver Burn Skin Score demonstrated a significant increase in skin quality in the group with dermal substitutes compared to the control group with non-substituted wounds. Range of motion was significantly improved in the group treated with the dermal substitute [35]. Temporary epidermal replacements may be beneficial in superficial to mid-dermal burns, whereas dermal replacements are the primary focus of current skin substitutes that are used for both acute and reconstructive procedures. It has been said that as the epidermis is life and the dermis is the quality of life provided by skin replacements.

Newer skin substitutes like Suprathel® and Aquacel® Ag BURN have now become available for use in hand burns. Suprathel is a copolymer consisting of poly lactide, trimethylene carbonate and caprolactone. It is a fully synthetic porous membrane that shows a large plasticity and imitates the properties of natural epithelium. It adapts instantly to the wound surface at body temperature. Because of this special property, it can be used also in critical and functional important regions like fingers or toes. Suprathel has been shown to accelerate the healing rates of intermediate thickness burns and allows for early mobilization [36,37]. Nylon-reinforced silver sodium carboxymethylcellulose (AQUACEL® Ag BURN) dressings were developed to be pliable and conforming for the management of partial-thickness burns. The AQUACEL® Ag BURN glove was applied to one hand and could remain in place up to 21 days until clinically indicated to change the glove. Of the 23 patients sixteen (70%) hand burns re-epithelialized fully over a mean of 15.6 days. Initial application was easy/very easy for 20 (87%) patients. Mean time for initial dressing application was 5.4 min. At final evaluation, most patients gave ratings of excellent/good for conformability (91%), overall glove performance (74%), and appropriateness of sizes (83%). Mean pain score from 0 (none) to 10 (worst imaginable) was 3.43 at baseline;

during the study, mean scores were 1.15 at rest and 2.29 during movement. Of 61 glove removals, most (72%) were easy/very easy, and 12% had fallen off. Adverse events (wound site or elsewhere) occurred in 15 (65%) patients. Treatment-related adverse events were wound pain (17%), maceration (9%), and stiff fingers (4%) [38-39].

10. CONCLUSION

Hand burns occur quite commonly, and the outcome of hand burns can significantly impact daily function and overall health-related quality of life. The management of hand burns is typically dictated by the depth of the burn. Superficial and partial-thickness burns that are likely to heal within a timely manner (2 to 3 weeks) are managed with wound care and aggressive range of motion to preserve hand function. Conversely, deeper partial-thickness and full-thickness burns that will require longer time to heal are better managed with wound excision and skin grafting. There have been a number of studies that have examined the optimal management and outcomes of patients with both partial-thickness and full-thickness burns of the hand. Many of the studies on surgical management of hand burns have focused on the timing of excision and the techniques of skin grafting. Regardless of burn depth, range of motion therapy and timing of splint immobilization are important considerations throughout the early and late post injury period as having mostly good outcomes.

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