HOW IMPORTANT IS HYDROTHERAPY? EFFECTS OF DYNAMIC ACTION OF HOT SPRING WATER AS A REHABILITATIVE TREATMENT FOR BURN PATIENTS IN SWITZERLAND

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SUMMARY. Burn rehabilitation using hydrotherapy can have multiple benefits for the burn patient. The therapy uses specific mineral enriched hot spring water and water jets with varied hydro-pressure to combat hypertrophy, inflammatory reaction signs, abnormal pigmentation, and, more specifically, redness and scarring. Standard operating procedures for burn rehabilitation have been developed and integrated into the Standard of Care at the CHUV hospital using localized hydro-mechanical stimulation of burn sites (20 minutes of alternating anatomical sites) followed by constant pressure large-bore and filiform showers targeting specific scarred areas. These therapeutic regimens are repeated daily for 2 to 3 weeks. Patients showed lasting effects from this regimen (up to 3-6 months), the results becoming permanent with more uniform skin structure, color and visco-elasticity in addition to a decrease in pruritus. The specifications of clinical protocols are described herein along with the virtues of hot spring hydro-pressure therapy for burn rehabilitation. The use of hydrotherapy, which has been a controversial topic among burn units across the world, is also discussed. In North America, hydrotherapy is defined only within the scope of in-patient wound cleansing and is thought to lead to microbial auto-contamination and bacterial resistance. In Switzerland and France the emphasis of hydrotherapy is on rehabilitation after the wound has closed.

Keywords: Hydro-Pressure Therapy (HPT), burn rehabilitation, mechanical-stimulation, scar management, hydrotherapy, hot springs

Introduction

Water has been used since 1550 BC for the attenuation of pain and treatment of burns in China (cold water containing tea extracts), but it was noted in 129-199 AC that cold water compresses were also used.[1] Even today, the first measure to take following a burn is to place it under cool running water (10-15°C) for ~10 minutes, or for as long as 20 minutes in countries, such as Australia, where the climate is hot. The term hydrotherapy has been adopted to describe medical use of water, either for early wound cleansing or for post-rehabilitation and treatment of scars. Literature is abundant concerning the negative connotations of hydrotherapy, mainly exposing the well-founded concerns about microbial contamination of open wounds in burn patients. We would like to define modern techniques utilizing water jets, varied hydro-pressure and specific mineral enriched hot spring water in the field of burn rehabilitation. We will also present several case studies using standardized procedures.

Hydrotherapy: the use of hot spring water for the treatment and healing of closed wounds

In France, for more than 100 years, hydrotherapy has retained a rehabilitative connotation, with the associated use of water jets and sulfurinated water from hot springs to combat burn induced hypertrophic skin, scarring, redness and pruritus.[2-5] Many European burn centers are mod-

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eled after those in France and perceive hydrotherapy as a main source of treatment for burn patients during the post-surgery phase of recovery once the wounds have closed.

In 1959, the notion of a "hot spring treatment" for burns was officially institutionalized by Dr. Lepinay at Saint-Gervais-les-Bains, France in order to tackle common burn-related symptoms such as inflammation, redness, hypertrophic scars and pruritus.[5] This kind of therapy begins only when open wounds have been completely closed and is therefore implicated in the rehabilitation steps of long-term burn care. Hydrotherapy at Saint-Gervais reduces inflammatory reaction in skin due to the mineral qualities of the local spring water: its mineralization is comprised mainly of sulfur and chlorine, with traces of strontium, potassium, magnesium, fluorine, iodide, iron, zinc and copper.[5] Saint-Gervais-les-Bains began close cooperation with two important burn centers at Saint-Luc and Edouard-Herriot in Lyon, France and have accumulated long-term clinical experience concerning post-hospitalization hydrotherapy for burn patients.

The first hot spring treatments at Saint-Gervais-les-Bains usually lasted for three weeks and patients would attend these centers once or twice a year during the first two years after a burn injury. A typical day of hydrotherapy treatment in Saint-Gervais would consist of the following: mornings would be dedicated to the treatments revolving around healing the skin (10 to 30 minutes of bathing, 10 to 15 minutes of sprays, 4 to 8 minutes of laminar water-flow showers [i.e. filiform showers] and physical therapy in the form of jet massages in pools) and the afternoons would focus on healing the psyche (resting at the center, outdoor physiotherapy sessions, excursions, and social outings).[5] Filiform showers are a crucial component of the hot spring treatments. They have been in use since 1913 when they were first documented in Bourboule, France.[2] On a daily basis, hot spring water at 35 to 40°C is projected at high pressure (8 to 18 kg/cm^2) through small openings (6/10th of a millimeter) for up to 8 minutes. Sonneck further highlights this point, demonstrating that the pulverization of water (a treatment that lasts from 5 to 20 minutes), as well as filiform showers, helped diminish hypertrophy in the skin of patients after 15 to 20 days of treatment.[6] The dynamic effect of the high-pressured water often reduces pruritus and induces an analgesic state by stimulating the nerve endings beneath the scar. We could also speculate that the scar of a burn patient is water permeable during the first months to years and, for this reason, penetration of oligo-elements from the water could modulate inflammation by reaching the superficial dermis and have a chemical effect on pruritus. The dynamic effect of high-pressured water also contributes to the restructuring of the collagen and elastin fibers of scarred tissue, promoting the formation of supple skin. Filiform showers also soothe the patient by eliminating pruritus, which has been reported to be the primary complaint of burn patients and one of the reasons why they might not wear their compressive garments properly. The high pressure needed for full effect must be adapted to the patient to obtain optimal water force massage and requires their active participation.[5]

Hydrotherapy: confined to burn wound cleansing

The use of hydrotherapy for burn wound cleansing dates back to the 17th century. Most American burn centers define hydrotherapy as wound cleansing for which water is used as a means of decontamination of the burn site, between bandage changes, in the form of immersion baths ("tanking") or showers during in-patient care.[7]

Unfortunately, in modern burn care, hydrotherapy is still largely associated with this "immersion bath" concept which explains why it has antagonized burn specialists in the United States and in many parts of the world. It has been commonly linked to the proliferation of a particular opportunistic pathogenic bacterium, *Pseudomonas aeruginosa,* since hydrotherapy is used on patients when their wounds are open and deep. This gram-negative pathogen that thrives in aquatic environments is a common threat in burn centers, causing possibly fatal nosocomial infections.

With regards to burn wound treatment with hydrotherapy, many articles can be found concerning the use of immersion tubs or the more recent integrated shower systems, while little information is available on the effects of the dynamic action of hot spring water as a rehabilitative treatment for burn patients.[8-11] We believe new terminology is necessary to distinguish this type of treatment for the rehabilitation phase of burn care. We therefore propose using the term Hydro-Pressure Therapy (HPT) in order to avoid confusion with the more general terms of hydrotherapy and hot spring treatments. We would further like to demonstrate that modern techniques utilizing water jets, varied hydro-pressure and specific mineral enriched hot spring water can revolutionize the field of burn rehabilitation to combat redness, pruritus, pigmentation and particularly scar hypertrophy.

Methods

The Saint-Gervais hydrotherapy center has acted as a model for our University Hospital (Centre Hospitalier Universitaire Vaudois, CHUV) in Lausanne to develop Clinical Care Pathways for burn rehabilitation. Our CHUV medical specialists (WR and MN) have collaborated with a local hot spring center since 2003 in order to develop specialized protocols for burn rehabilitation. The center at Lavey-les-Bains, a Swiss hot spring therapy center is within close proximity to CHUV's burn center, allowing for the subsequent protocol development and case studies to be easily followed. Lavey-les-Bains (www.lavey-les-

bains.ch/fr/medical) has been administering "general hot spring care" since 1833, and assumed greater responsibilities after the drastic toll of injuries brought about by World War II on the European populace. The renowned water source at Lavey-les-Bains, discovered in 1831 (global mineral content is 1,320.21 mg/L: Cations 409.24 Anions 809.16, metasilic acid 86.21 and orthoboric acid 15.6), provides an antioxidant healing effect for burn patients. The water's sulfated, chloridated and fluoridated qualities promote an anti-inflammatory pathway for recovery. Burn treatments offered at Lavey-les-Bains focus mainly on the elimination of hypertrophic and inflammatory scarring, redness and pruritus. The techniques implemented in order to address the aforementioned are analogous to those found at Saint-Gervais with some adaptations (*Fig. 1*). To dissociate hydrotherapy from previously used terminology for wound cleansing, we have defined this therapy in the Clinical Care Pathway for burn care and rehabilitation as Hydro-Pressure Therapy (HPT) with macro- and micro- stimulation of burn wound sites including hydro-massage baths, large bore and filiform shower regimens.

In *Fig. 1*, the daily protocol for HPT is described. Hydromassage bath sessions last approximately 20 minutes and mechanical stimulation of all body regions are accomplished by programmed and incorporated water jets at 2 minute intervals beginning at the upper torso and finishing at the feet with 10 total cycles. This phase is completed in order to promote the mobilization of articulations and create a soothing and relaxing environment for the patient. Immediately following, a single, large-bore shower

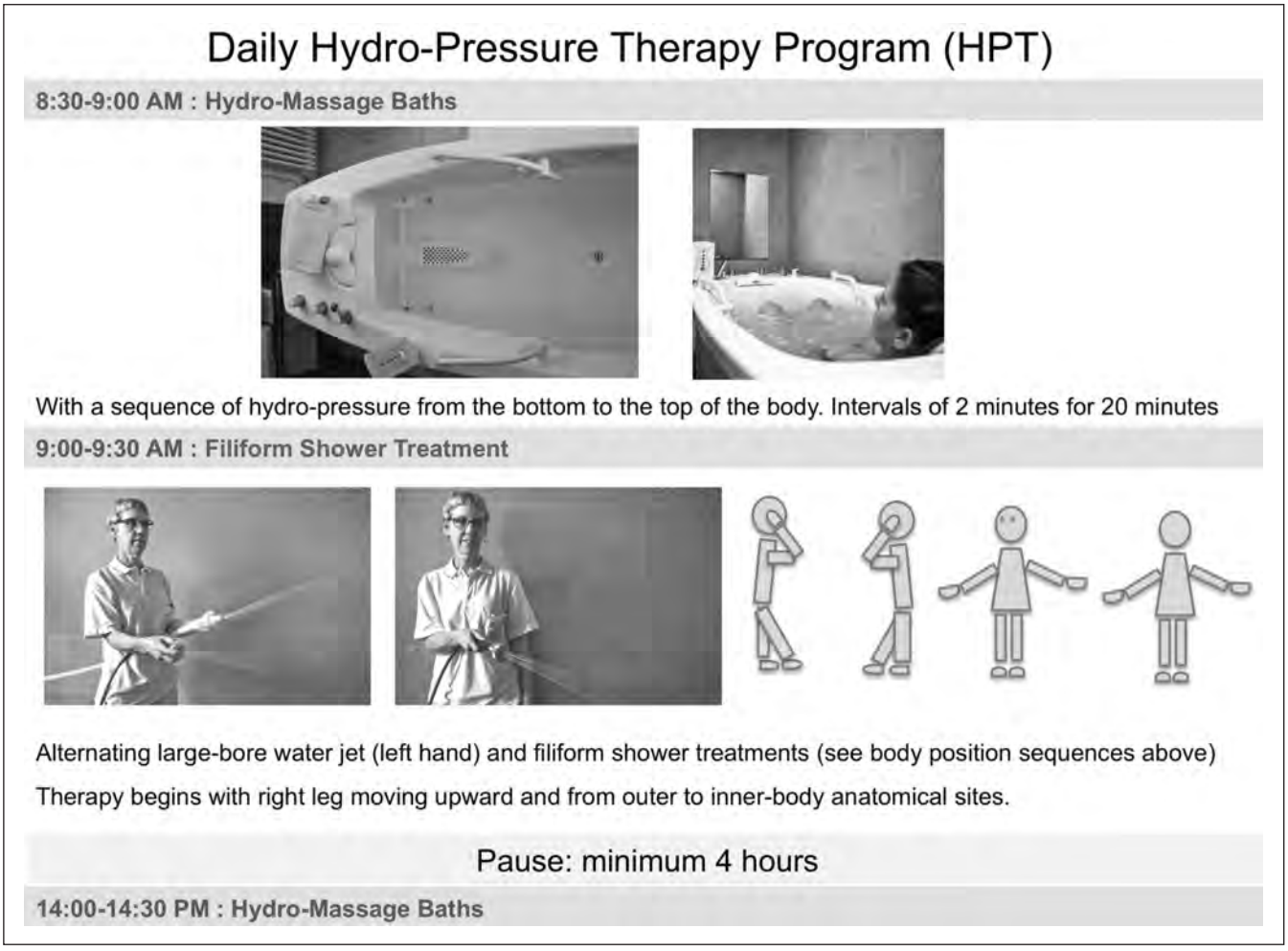


Fig. 1 - Hydro-Pressure Therapy program on a daily basis.
Beginning each morning, hydro-massage baths (20 min) are implemented with 2 minute cycles starting at the torso and ending at the feet. Following this part of the regimen, the large-bore shower is used on all anatomical sites with 4 specific body positions as illustrated, moving from the bottom to top. Filiform showers are then employed in a sweeping motion following the same 4 specific body positions emphasizing local therapy on damaged tissues. Following a minimal pause of 4 hours, the hydro-massage bath (20 min) is repeated as described above.

is alternated with filiform showers equipped with high pressure parallel water jets (measuring 0.4 to 1 mm in diameter) and are projected at 3 kg/cm^2 at 34 °C. By varying the distance between the jets and the patient, the cleansing mechanism of the scar can alter from light contact to a slight dermabrasion and is the core of hydrotherapy at the center. This treatment is provided by a specialized therapist and customized treatments are assured for specific injured tissue areas. This phase of treatment lasts for 30 minutes instead of the 5-8 minutes proposed by the French centers. This also allows the time necessary to alternate for a complete cycle of full body coverage with the large-bore shower followed by the filiform shower with a sweeping motion to cover specific damaged tissue. After these two sessions, patients receive customized massages and physical therapy lasting from 30-60 minutes. These treatments, taken together, aim at mechanically stimulating the affected areas in order to restore mobility and adequate vascularization. There is a minimum pause of 4 hours and the Hydro-Massage bath session is repeated in the afternoon to complete the full daily therapeutic protocol. The average length of treatment at Lavey-les-Bains is two to three weeks, with a recommendation to undergo 3 to 5 treatments during the first 3 years post-burn for optimal effect.

Skin assessment with Vancouver Scar Scale and photography

Skin in various burn patients was assessed for overall structure, coloration, visco-elastic properties by the pinch-test, and presence and duration of pruritus before and after hydro-pressure therapy. The Vancouver Scar Scale (VSS) was employed to give an average score for pliability, vascularity, pigmentation and height of the scars in each patient before and after HPT therapy regimes. The photos were taken using standard material (Sony DSC-W220) so that white balance could be maintained. The same distance was used for each series to assure high definition photography.

Results

In all of the case studies presented and in our overall experience, there were obvious visible and physical ameliorations with regards to the viscoelastic properties of the skin, skin structure, color and diminished pruritus. Overall, 31 patients with a total of 40 HPT sessions, encompassing 84 weeks of treatments, have been processed in the last couple of years (average treatment duration 2.8±0.48 weeks) (*Table I*). None of the patients have had any treatment-related complications, infections or treatment interruptions. The average age of the patients during the treatment was 26.8±16.5 years. For these patients, we have made an overall assessment of scars with an average score based on VSS (*Table II*). In the 31 patients, a total of 75 scar sites were analyzed before beginning HPT and at 2-3 weeks post-therapy. Anatomical regions included 10 sites on the head and neck region, 22 on inferior limbs and 43 on superior limbs of the body. Outcome measures were done for all patients, which are represented in *Table III*, along with their related statistics. Overall, there was a re-

Table I – General patient data
Patient data including the number of patients and gender, average age and treatment duration. Scar anatomical sites treated are divided into categories

Number of patients	**31**
Male	19
Female	12
Age (average of years)	**26.8±*16.5* (4-70)**
Treatment duration (average of weeks)	**2.8±*0.48* (1-3)**
Scar sites	**75**
Head and neck	10
Inferior members	22
Superior members	43

Table II – Modified Vancouver Scar Scale
Categories used and scale reference for scoring

	Scar apearence	Score
Pliability	Normal	0
	Supple	1
	Yielding	2
	Firm	3
Vascularity	Normal	0
	Hypopigmentation	1
	Mixed	2
	Hyperpigmentation	3
Pigmentation	Normal	0
	Pink	1
	Red	2
	Purple	3
Height	Flat	0
	1 : <2mm	1
	2 : >2 < 5mm	2
	3 : >5 mm	3

Table III – Vancouver Scar Scale Outcomes: Percentage of amelioration
Average VSS outcomes for all patients before and after treatment periods showing percentage of improvement following HPT therapy

	Before treatment	After treatment	Difference
Pliability	2.87 ± *0.64*	1.60 ± *0.66*	44%
Vascularity	2.14 ± *0.61*	1.03 ± *0.44*	52%
Pigmentation	2.16 ± *0.58*	1.08 ± *0.68*	50%
Height	1.79 ± *0.70*	1.08 ± *0.52*	39%

duction of all VSS measures with 39-52% amelioration of skin following HPT.

Several case studies are reported from consultation with Dr. Michael Norberg orthopedic surgeon at CHUV and rehabilitative expert at Lavey-les-Bain (Lavey Medical thermal center). Patients were photographed before and after HPT treatment regimens, and at different times during follow-up and rehabilitation sessions for physical therapy, to allow both the short and long term benefits of the thermal cure to be observed. We have examined and summarized hypertrophic scarring, redness and pruritus from routine photographs and patient accounts and records. Hypertrophy can be defined as an increase in volume of the scarred tissue due to the enlargement of cells. In the context of burn scarring, hypertrophy is characterized by deposits of excess collagen, creating a raised scar, forming at the site of the burn. Hypertrophic scars are pigmented (red) and may produce itching (pruritus).

Case 1

Born in 1974, this patient was a victim of a 2nd degree burn from a gas explosion on a boat in September, 2011. The patient was burned on 36% of his total body surface area (TBSA) and received a 3-week standardized hot spring therapy approximately 8 months after the incident. The scar resulting from the meshed grafting procedure improved (*Fig. 2*). The patient's calf is heavily marked by a grid-like pattern from the meshed grafting procedure, primarily noticeable from the small black dots evenly printed on the calf, surrounded by sequellae from the donor skin's borders. When observing the 'after' image, the remnants of the donor skin's border are no longer apparent, with a decrease in volume of the hypertrophic scarring of that region and a restoration of natural skin pigmentation. The patient files also reported a reduction in pruritus and a renewal of skin elasticity, with the patient reporting that anti-pruritic affects lasted 4 to 6 months. For all VSS pa-

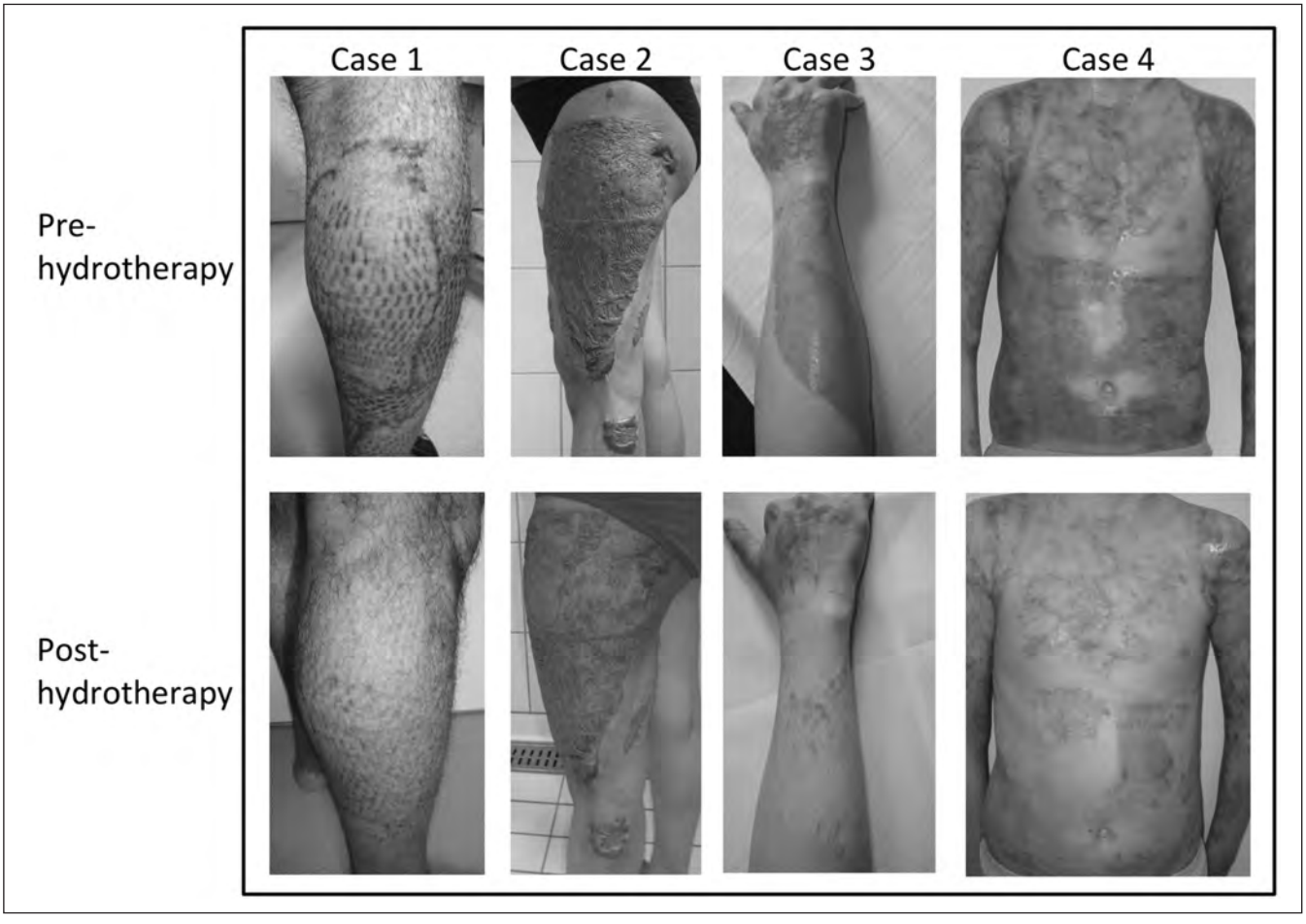


Fig. 2 - Case reports of 4 patients before and after Hydro-Pressure Therapy Programs for 2-3 weeks.
Photographs of 4 patient cases are represented showing the beginning stage of tissue damage and the appearance at the end of the 3 week session of HPT (immediately following last session).

Table IV – Vancouver Scar Scale: Case Studies
VSS scores represented for anatomical sites for case studies presented before and after 2-3 week HPT treatments

	Burn site	Pliability		Vascularity		Pigmentation		Height	
		BT	*AT*	*BT*	*AT*	*BT*	*AT*	*BT*	*AT*
Patient 1	Calf	4	2	2	1	3	1	2	1
Patient 2	Thigh	4	2	3	2	3	2	3	2
Patient 3	Arm	3	2	2	1	3	1	3	1
Patient 4	Face	3	2	2	1	2	2	2	1
	Shoulder	2	1	2	1	2	1	2	1
	Thorax	1	1	2	1	3	1	2	2
	Legs	2	1	2	1	1	1	*n.d.*	*n.d.*

BT= Before HPT treatment
AT= After HPT treatement
n.d.= not done

rameters, there was noticeable improvement (*Table IV*).

Case 2

This patient, born in 1985, sustained 2nd degree burns to her left thigh. She received various hot spring therapies at Lavey-les-Bains, the first one occurring 9 months after her burn injury. The photographs from *Fig. 2* were taken 21 months post-burn, before and after the standard 3-week hydrotherapy treatments. They involve the aforementioned techniques and highlight improvements on various fronts. From her patient file, reduced pruritus and ameliorated skin elasticity were reported during her second round of treatment. As seen in *Fig. 2*, hypertrophic scarring diminished in multiple sites, such as both the left and right quadrants of her upper thigh. Skin uniformity is also noted on the aesthetic front, since the appearance of a grid-like pattern caused by the meshed grafting subsided after the cure. Sequellae marking the graft edges decreased in size post-hydrotherapy treatment. Finally, the overall redness of the scars also appears to have diminished and elasticity of the skin increased. Anti-pruritic effects were seen for up to 4 to 6 months. For all VSS parameters, there was noticeable improvement (*Table IV*).

Case 3

This patient, born in 1968, received the standard 3-week hydrotherapy treatment in October, 2012 after being burned in July, 2012 by a gas explosion. The patient sustained a 2nd degree burn on the right forearm and dorsum of the right hand. A marked decrease in redness can be seen in *Fig. 2*, especially on the forearm region and around the wrist. There was a marked decrease in erythema over all sections of the damaged tissue, indicating that the scar was healing. Also, from *Fig. 2*, a decrease in hypertrophic scarring can be observed on the dorsum of the hand. This specific case demonstrates hydrotherapy's ability to restore mobility to even the most delicate of articulations, such as the fingers on the hand, without damaging the sensitive tissue and increasing visco-elastic properties of the skin. Pruritus was lessened for approximately 6 months. For all VSS parameters, there was noticeable improvement (*Table IV*).

Case 4

This 10-year-old patient sustained 2nd and 3rd degree flame burns with 45% TBSA involvement after a barbeque accident in 2012. Before attending Lavey-les-Bains for her first hot spring treatment, all of the scarred tissues, namely on her lower face, neck, shoulders, arms, thorax, stomach and back, were red and itchy. Furthermore, some areas, notably on the lower area of her face and her chest, were hypertrophic. The hydrotherapy she received was a combination of filiform showers, hydromassages, and physical therapy on a daily basis during the standard 3-week treatment period. *Fig. 2* highlights the important ameliorations that were noted post-hydrotherapy. There was decreased hypertrophy on the patient's lower cheeks and thorax and a significant decrease in skin coloration (redness) to a large extent on most of her body, which can be clearly seen on the patient's stomach, for instance, where erythema was attenuated. From the patient records it is important to point out that the decrease in pruritus allowed the patient to be more willing to wear her compression garments and face mask, which are crucial for full recovery. The overall effects of Hydro-Pressure Therapy lasted several months. There were multiple sites analyzed in this patient and for the most part there was amelioration. Some areas had no change in pliability (thorax) or did not change in pigmentation (face and legs) (*Table IV*).

Discussion

Hydrotherapy does not possess a consistent definition across borders. Its association with in-patient burn wound cleansing, most notably in North America, has hampered discussion of its possible use for rehabilitation. At our Uni-

versity Hospital, we have developed Clinical Care Pathways for burn treatment and rehabilitation by partnering with a local thermal center in Lavey-les-Bains. We have incorporated HPT regimens as a major out-patient treatment for adult and pediatric burn patients following the model established in Saint-Gervais, with some modifications of the daily treatment regimen. As can be noted from the 4 case reports, HPT plays a crucial role in eliminating hypertrophic scarring, which can form due to surgical treatment of the burn site or due to the burn itself. Additionally, hot spring therapy and HPT help alleviate redness and pruritus while creating an environment that is conducive to promoting self-assurance in the patient. In France, hot spring water and HPT are accepted as an important part of burn therapy with 2 annual sessions eligible for reimbursement through social insurance. It is essential that this therapy be registered within the Clinical Care Pathway to help determine the number of sessions that could be reimbursed to the patient from insurance.

Water has the greatest impact on recovery when it is used in three distinct treatment types: bathing, filiform showers, and associated physiotherapy. Bathing in clean water is usually performed in burn centers when the scarring process is still underway. It mainly allows for dressing changes to be less painful.[5] Physiotherapy, supplemented by underwater jets, helps restore the skin's functionality and appearance while improving the patient's abilities to perform daily activities independently. These jets are found in individual or collective pools. Jets promote skin elasticity and enhance the organ's supple nature. Jet pool rehabilitation also provides the opportunity for patients to start building their self-esteem by becoming familiar with their new bodies so they can begin the process of scar acceptance. Activities in collective pools foster a sense of belonging and promote re-integration by exposing the patients to others who have undergone similar situations and bear similar reminders of their trauma.[5]

Conclusion

Hot spring HPT plays a crucial role in the recovery of burn patients by contributing to the superficial improvement of the affected skin as well as by fostering a general sense of personal well-being. By targeting both the restoration of the skin's physical properties and the strengthening of the patient's psyche, their body's ability to heal is increased. Hydrotherapy is an umbrella term for many treatments that contribute to the complex process of a burn patient's recovery. Filiform showers, jet massages and hot spring water baths have separate abilities to address specific needs in the burn recovery process. By standardizing these HPT therapeutic options, burn patients will have greater access to treatment, and the resulting overall improvement of the rehabilitation process will make the patient's reintegration into school, daily work and living activities easier.

RÉSUMÉ. L'hydrothérapie pendant la réhabilitation des patients atteints de brûlures peut avoir plusieurs avantages. Le point focal de cette thérapie est l'utilisation d'une source d'eau thermale de source chaude enrichie en minéraux et de jets d'eau avec une variation de pression afin de lutter contre l'hypertrophie, les signes de réaction inflammatoire, une pigmentation anormale et en particulière des rougeurs et des cicatrices. Pour la réhabilitation des brûlures, les procédures d'utilisation normalisées ont été développés et intégrés dans le standard des soins dans notre hôpital. Ces procedures comportent une stimulation hydro-mécanique localisée sur les sites de brûlures (20 minutes en alternant les sites atomiques), suivie par une pression constante localisée directement sur les cicatrices faite à l'aide de douches de gros diamètre et puis de douches filiformes. Ce régime thérapeutique est répétée quotidiennement pendant 2 à 3 semaines. Après le traitement, les patients ont pu observer une structure plus uniforme de leur peau ainsi qu'une amélioration de sa couleur et de sa visco-élasticité, aussi bien que la diminution du prurit, et ce durant 3 à 6 mois. Ici nous présentons les spécificités de notre protocoles cliniques et les avantages d'une traitement d'eau thermale de source sous pression pour la réhabilitation des patients brûlés. Nous parlerons également de l'utilisation de l'hydrothérapie, qui est un sujet de controverse parmi les unités de soins aux brûlures à travers le monde. En Amérique du Nord, l'hydrothérapie est définie uniquement dans le cadre du nettoyage des plaies des patients hospitalisés, et elle peut conduire à l'auto-contamination microbienne et la résistance bactérienne. En Suisse et en France, l'hydrothérapie concerne uniquement la réhabilitation des plaies une fois celles-ci fermées.

Mots-clés: Hydro-Pressothérapie (HPT), réhabilitation, stimulation-mécanique, gestion de la cicatrice, l'hydrothérapie, sources chaudes

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Acknowledgements. We thank the Sandoz Family Foundation, the Foundation S.A.N.T.E and FLAVIE (Swiss Burn Association) who have helped finance our burn transplantation program to date. We would like to dedicate this study to Lady Kristina and Sir Roger Moore (the active Godparents of the Applegate lab); our partners in burn prevention who have a particular interest in burn treatments and rehabilitation for children.

This paper was accepted on 23 July 2014.