Psoriasis Treatment in a Geothermal Lagoon. Five Years Experience from the Blue Lagoon in Iceland

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Introduction

The Blue Lagoon is situated in the Reykjanes peninsula in Iceland. It is the landward extension of the Reykjanes ridge, which in turn is a section of the Mid-Atlantic Ridge where the two continental plates meet. The peninsula consists mainly of porous volcanic lava, making it permeable to water. Sea-water therefore slowly seeps deep into the aquifers. The geothermal area called “ Svartsengi” (meaning Black Meadows in Icelandic) on the peninsula, is highly active with regards to this process. A geothermal power plant was built in 1976 in Svartsengi and a lagoon called the Blue Lagoon was formed close to the plant when warm salt fluid was discharged to the lava field (Fig. 1). An employee in the geothermal plant suffering from psoriasis gradually improved when he rubbed the white mud onto his psoriasis plaques while bathing in the pleasantly warm lagoon. In the following years several people tried to cure their skin diseases by bathing in the lagoon and many of them claimed some beneficial effect from the bathing. Three clinical studies, sponsored by the Icelandic government, have been carried out, in order to determine if bathing in the lagoon has an effect on psoriasis. The biology of the lagoon has also been studied extensively. We have not found in the literature any biological studies showing the existence of similar biological phenomena. Geothermal brines are widely used in the world for energy production. They often contain toxic substances like heavy metals (1). This, however, is not the case in the Blue Lagoon. The lagoon and its surroundings have become a popular tourist attraction with over 100,000 bathers visiting each year in addition to hundreds of patients with skin diseases.

The Blue Lagoon

The Svartsengi power plant draws fluid from wells drilled deep into a geothermal reservoir (2). The 24°C fluid in the reservoir is a mixture of 65% sea-water and 35% fresh-water. The chemical composition of the salt fluid (brine) deep in the aquifers is however altered by interaction with the rock formation (Table 1). Precipitation of magnesium silicates has reduced the magnesium concentration by a factor of one thousand, and dissolution of the rock has raised the concentration of silica (SiO) roughly one hundred fold, to approximately 430 mg/kg. The fluid is separated into a steam phase and liquid phase at the surface. The steam phase is used to produce electricity and the liquid phase is used to warm up fresh water, which in return is used to heat up the houses in the neighbouring communities (3,4). After the fluid has gone through steam separators and heat exchangers, it is discharged into the lava field close to the plant at a rate of 900 m³/hour and a temperature of 7°C. Most of the fluid seeps down into the ground through fissures in the lava, but some evaporates, reducing the temperature further. However, enough water remains on the surface to form a pond or lagoon. The average retention time of the saltwater in the lagoon is 40 hours. On cooling, the liquid becomes supersaturated with respect to silica, which then precipitates to form a white mud. This seals the fissures in the lava causing the lagoon to spread to the present size of approximately 0.2 km wide and a few km long with depth of 1-3 m. The silica concentration in the lagoon water is about 135-140 mg/kg. Some of

The pictures have been removed to save space

Fig 1. The Blue Lagoon, on the Reykjanes peninsula in Iceland.
Table I. The chemical composition (mg/kg of fluid) of the fluid in the Blue Lagoon:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH/temp °C</td>
<td>7.7/24</td>
</tr>
<tr>
<td>SiO</td>
<td>137</td>
</tr>
<tr>
<td>Na</td>
<td>9280</td>
</tr>
<tr>
<td>K</td>
<td>1560</td>
</tr>
<tr>
<td>Ca</td>
<td>1450</td>
</tr>
<tr>
<td>Mg</td>
<td>1.41</td>
</tr>
<tr>
<td>CO₂</td>
<td>16.5</td>
</tr>
<tr>
<td>SO₄</td>
<td>38.6</td>
</tr>
<tr>
<td>H</td>
<td>5.00</td>
</tr>
<tr>
<td>Cl</td>
<td>18 500</td>
</tr>
<tr>
<td>F</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Total dissolved solids mg/kg fluid: 31900

The silica in the water polymerises and forms colloidal particles, which precipitate on the bottom of the lagoon to form a layer of white soft mud. The fluid in the lagoon has a white-bluish colour. These silica particles scatter light intensely, giving the pond a name: The Blue Lagoon.

The biology of the lagoon

The chemical composition of the fluid in the lagoon is given in Table I (5). The mean temperature in the lagoon is 37°C but strong winds can cause some fluctuations while rain and air temperature have only a marginal effect. The mean pH is 7.5 and the salt content is 2.5% (6). These conditions might provide a favourable environment for a number of organisms. This is, however, not the case (6). The only organisms found are some cyanobacteria and a few species of prokaryotes. The dominating algae is a blue green algae called Leptolyngbya erebi var. thermalis, belonging to the Cyanobacteria species. These algae grow very fast on the long silica molecules in the warm natural surroundings of the lagoon, and are not found under similar conditions anywhere else in the world (6). Due to the many visiting bathers and as well as the lack of artificial disinfectants, one would expected to find enteric bacteria in the lagoon. However, the only type of bacteria isolated from the lagoon is a Gram negative rod belonging to the Roseobacter species. This bacterium has recently been categorised more specifically and has been named silicibacter lacuscaerulensis, which means "The silica bacterium from the lagoon with the Blue Colour". It has been confirmed that this is a new bacterium, which has not been identified elsewhere in the world. Further studies are needed on this new bacterium which has adapted itself so well to these harsh surroundings. It seems that the bacterium only grows if water from the Lagoon is added to the agar. Preliminary reports from the Department of Immunology at the University of Iceland have shown that the supernatant from this bacterium seems to have an effect on the immune system. No human coliform bacteria or environmental bacteria have been isolated from the lagoon and these bacteria are rapidly killed in fluid from the lagoon. This has also been confirmed by the bacterial monitoring regularly done by the health authorities. The experience of the dermatologists working at the outpatient clinic at the Blue Lagoon confirms that wounds rarely get infected and infected wounds heal quickly. No fungi or plants have been found or isolated in the lagoon (6,7).

The few organisms that have adapted to this harsh environment can, however, proliferate to high numbers. The explanation to the simplicity of the flora may be due to a number of coexisting factors like the high salt content, high temperature and silica particles increasing the exposure of the bacteria to UV-light (8).

The bathing facilities

A more controlled situation was required for the purpose of studying the effect bathing has on various diseases. A new bathing facility was therefore made for this purpose (Fig. 2). This facility is situated beside the original lagoon. The new "pool" measures 25 x 6 metres, with an even bottom, covered with 10-20 cm layer of soft silica mud with abundance of blue green algae. Adjusting the inflow of hot water controls the temperature. No difference has been found between the two lagoons regarding salts, silicates, algae, bacteria or pH (9).

The effect on healthy skin and psoriasis

The effect of bathing on healthy skin

Like all prolonged hot baths, bathing in this lagoon can make normal skin dry. The silicate particles, which pre-

Fig 2. The Blue Lagoon in Iceland outpatient clinic.
cipitate to form very soft white mud on the bottom, are often rubbed on the skin. The abrasive effect of the fine silicate particles makes the skin quite soft but at the same time dry. Therefore it is necessary to compensate with emollients after bathing. Should the head be dipped into the water the hair shafts will be covered with silicates. This makes the hair dry and uncontrollable for a few days after bathing. To prevent this bathers are advised to use hair conditioner before dipping their heads in the water. Like all hot baths, prolonged bathing can cause dizziness when emerging from the water.

The effect on psoriasis. The first study
Two preliminary studies were conducted on the effect of the bathing in the lagoon on psoriasis (10,11). Both studies indicated some beneficial effect on psoriasis, which led to more thorough studies. The first serious study was done in 1992. Twenty-eight psoriatic patients, aged 16-75, from different parts of Germany and selected by German dermatologists, were treated in the lagoon (12). All were treated at the same time. No other skin treatment was allowed, but moisturisers were permitted. Patients with plaque-psoriasis or extensive guttate psoriasis of more than one year’s duration, with more than 10% of the body surface involved were included. All psoriasis treatments were stopped 4 weeks prior to the study. The patients bathed three times a day for one hour at a time for three weeks. The study was carried out in August-September, to minimise the effect of UV-radiation. They were advised to rub the silica mud on the skin while bathing. A quick shower was taken afterwards. The skin was examined upon arrival, after one, two and finally after 3 weeks. The severity of the disease was determined by the Psoriasis Area and Severity Index score (PASI) as described by Frederikson & Pettersson (13) and by photographs. Twenty-seven patients, 15 males and 12 females, 25 to 62 years of age (mean 46.1 years) entered the study. The mean duration of their psoriasis was 25.5 years. All had received psoriasis treatment in the previous year. The mean PASI score fell significantly the first week of treatment (Fig. 3), from an average value of 16.1 to 10.8 (p=0.01). At three weeks 5/26 patients had an improvement rate of at least 75%. At that time psoriasis improved by less than 35% or deteriorated in only 4/26 patients. A few patients described mild stinging, itching or burning during or shortly after bathing. Many patients noticed dry skin, which was easily remedied with emollients. These results showed that bathing in the Blue Lagoon for only three weeks had a favourable effect on psoriasis although in some cases it was not sufficient as a single treatment. The algae Leptolyngbya erebi var. thermalis, which is found in the lagoon, had been grown in a greenhouse under controlled conditions. It has been freeze-dried and minced and thereafter applied to the lesions of 12 psoriasis patients in lotion and in cream form but up to this time without any effect on psoriasis (unpublished results from the authors).

Adding UVB treatment to the bathing. The second study
From these results it was evident that further studies were needed. It was noted that the scaling decreased very rapidly and the lesions became thinner already after two weeks, but thereafter, improvement slowed down. To take advantage of this the study was decided that adding UVB would be a good choice. Twenty-three psoriasis patients (aged 17-64, median 46; 10 females and 13 males) were treated all at the same time (14). The mean duration of their psoriasis was 23 years (range 4-43 years). All of them had been treated for psoriasis in the previous year. The control group consisted of 17 Icelandic psoriatic patients (aged 17-81, median 43; 8 females, 9 males). The mean duration of psoriasis was 21 years (range 2-60 years). All had received psoriasis treatment during the previous year. The treatment schedule in the Blue Lagoon was the same as in the first study but instead of 3 weeks they were treated for 4 weeks. UVB treatment was given daily 5 times a week at the treatment facility. The control group was only treated with UVB 5 times weekly for 4 weeks with the same UVB source (Philips TL 100W/01) but did not bathe in the lagoon. Moisturisers and emollients were permitted. The patients were evaluated with the PASI score weekly. The PASI values from both studies are shown in

Fig 3. The PASI scoring during treatment in the Blue Lagoon daily and 3 times a week combined with UVB and when treatment is given with UVB alone, presented as percentage of the original
In 1996, 3611 treatments were given to psoriasis patients at the Lagoon. The majority of the patients were from Iceland but individuals from other countries as well as groups from many countries were treated at the Lagoon. All patients are evaluated with PASI scores before and after treatment in the Lagoon. The results from the routine treatments are in accordance with the studies described above. Patients staying at the Lagoon and receiving treatment daily are generally quicker to heal, as is expected. These good results are also seen when patients are being treated in a quiet hospital environment. Many of the outpatients treated at the Lagoon have been treated with many of the ordinary treatments before being sent to the Lagoon for treatment. The general feeling of the dermatologists at the treatment facility is that this new treatment modality is comparable to PUVA regarding the potency of the treatment.

Discussion

The studies on the "Blue Lagoon" described above have shown that the bathing has a beneficial effect on psoriasis.
riasis (12). This is, however, apparently not enough in many cases to treat psoriasis without other treatment modalities used concomitantly. Combination with UVB (14) increases the efficiency of the treatment significantly and is clearly better than using UVB alone. The scaling decreases very quickly along with rapid thinning of the lesions in the first 2 weeks of bathing, it is therefore not surprising to see that adding UVB has such a good effect. Natural UV phototherapy and bathing in salt water has been shown to have beneficial effect on psoriasis (15,16,17). In the Blue Lagoon there are some noticeable differences compared to the usual UV thalassotherapy. The silica brine and the minerals of the Lagoon are different and not found in other areas of the world (6). The algae (Lyngbya estuaria var. thermals) and bacterium (silicibacter lacuscaerulensis), are unique in this context and not found under similar conditions anywhere else. The third difference is the natural sun in Iceland that is not reliable for treating psoriasis except for a short period in the summer. All the studies were done during the winter or autumn months to exclude UV effects from the sun. Hot baths are very common in Iceland as in many other countries but reports of improvement of psoriasis in hot baths are not well documented. The silica mud has an abrasive effect when rubbed on the psoriasis plaques. This probably causes the early desquamation seen (11). The erythema, however, decreased with the desquamation but did not increase as might be expected when the scaling decreases and the inflamed lesion becomes evident (17). In spite of the many treatment modalities available for psoriasis there is no treatment suitable for all patients. Some patients are generally opposed to the use of drugs or they may not tolerate the sun so other treatment modalities have to be explored. Psoriasis patients from many countries, seeking alternative treatment modalities and balneotherapy, are already being treated in the Blue Lagoon. In Iceland it is frequently used to treat psoriasis and other disorders of keratinisation when other treatments, like UVB, have failed. The treatment facility at the Blue Lagoon is fully licensed by Icelandic Health authorities for treatment of skin ailments. It is concluded that bathing in the Blue Lagoon, with the addition UVB light, is an effective and useful alternative treatment of psoriasis, and better than UVB treatment given alone.

References