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ORIGINAL ARTICLE

THE EFFECT OF UVB RADIATION ON SKIN MICROBIOTA IN PATIENTS WITH ATOPIC DERMATITIS AND HEALTHY CONTROLS

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ABSTRACT

Objectives. To investigate *Staphylococcus aureus* and *Staphylococcus epidermidis* quantitatively in adult patients with atopic dermatitis and in healthy controls treated with UVB radiation.

Study design. Twenty-three adult patients (of these, 3 were excluded) with flexural atopic dermatitis and 20 healthy controls were randomly selected at the outpatient clinic of the Dermatological Department, University Hospital, North Norway.

Methods. Adult patients with atopic dermatitis (n=20) and healthy controls (n=20) were given 20 UVB treatments. Bacterial samples were collected before treatment, after 4 weeks of treatment, and finally after 2 weeks follow-up.

Results. The main bacteria found were *Staphylococcus aureus* and *Staphylococcus epidermidis*. 16 of the 20 patients with atopic dermatitis had *Staphylococcus aureus* in lesional skin and 12 in non-lesional skin. None of the healthy controls had *Staphylococcus aureus* in the sample from the flexural elbow. The *Staphylococcus aureus* counts decreased (not significant) in lesional skin after 4 weeks of treatment and *Staphylococcus aureus* counts were slightly higher after 2 weeks follow up. The same figures were also seen in non-lesional skin and forehead.

Conclusions. *Staphylococcus aureus* is widely colonised in the skin of atopic dermatitis patients, but is rare in healthy adults. UVB treatment decreases the *Staphylococcus aureus* count in patients with atopic dermatitis. (*Int J Circumpolar Health* 2008; 67(2-3):254-260)

Keywords: atopic dermatitis, anti-microbial effect, phototherapy, *Staphylococcus aureus*, *Staphylococcus epidermidis*

INTRODUCTION

Atopic dermatitis (AD) is a multifactorial, genetic skin disorder characterized by pruritus and eczema (1,2). Although a genetic predisposition is essential for the development of atopic dermatitis, epidemiological data suggest that environmental factors (i.e. pollution, indoor and outdoor allergens, cold climate and poor indoor ventilation) may be crucial in the expression of the disease (3). *Staphylococcus aureus* (*S. aureus*) has been implicated as an environmental factor in the aetiology of AD (4). *Staphylococcus aureus* is not just a triggering factor, but seems to have a disease sustaining effect related to the potent exotoxins, known to act as super antigens (5). These super antigens bind directly without antigen processing to HLA-DR molecules antigen presenting cells, such as macrophages or dendritic cells, and cause release of cytokines and mediators of inflammation via the subsequent activation of T-cells (5,6).

The skin of patients with AD seems to be a favourable environment for aerobic bacterial colonization. When sufficient quantities of *S. aureus* are present, exacerbation of the eczema and serious discharge of the disease is reported (6).

The purpose of this study was to investigate both *S. aureus* and *Staphylococcus epidermidis* (*S. epidermidis*) quantitatively in patients with AD and in healthy controls. Furthermore, we assessed the effect of UVB radiation on the density of *S. aureus* and the potential for clinical improvement.

MATERIAL AND METHODS

23 patients with flexural AD (who fulfilled the AD criteria of Hanifin and Rajka (7)) were randomly selected from the outpatient clinic of the Dermatological Department, University Hospital, North Norway. During the study 3 were excluded, i.e. 2 females due to oral antibiotic treatment and 1 male (due to a requirement for photochemotherapy (PUVA) treatment). The trial comprised of 20 patients, 11 females and 9 males, whose age ranged from 18 to 30 years (mean age 23.4 years). 20 healthy adults from the department of administration, University of North Norway, 12 females and 8 males, with an age range from 24 to 45 years (mean age 33.8 years) served as controls and fulfilled the inclusion criteria (>18 years old, healthy, non-atopic, not working in clinical department).

The following exclusion criteria were applied: Ultraviolet radiation (UVR) treatment, sun bathing or systemic corticosteroids 1 month before the study commenced; use of topical corticosteroids group II-IV 2 weeks prior to and during the study; use of oral or topical antibiotics or antimycotics 1 month prior to and during the study; and use of topical preparations containing salicylic acid 2 weeks prior to and during the study.

The patients were instructed not to use any topical preparations other than hydrocortisone 1%, Essex cream, Apobase cream or liquid paraffin.

The study was approved by the Ethical Committee of the University of North Norway, Tromsø.

Clinical assessment

A dermatologist (LKD) assessed all patients according to the SCORAD index (Severity Scoring of AD) before treatment, after 4 weeks of treatments (20 UVB radiations) and after 2 weeks follow-up. Each time the SCORAD index calculated the degree of erythema, oedema, oozing/crusts, papulation, excoriation, lichenification and dryness, pruritus, sleep loss and also the extent of inflammation (8). Blood was sampled from the case and control groups to determine total serum IgE, Phadiatop (Pharmacia CAP-system) and Fx5 (Pediatric panel with five food allergens, Pharmacia CAP system, Pharmacia AB, Uppsala, Sweden). In the case group 12 patients had elevated serum IgE $>120 \text{ k}\mu\text{l}$, 2 patients had asthma, 1 had asthma and allergic rhinitis, 13 had allergic rhinitis and the remaining 4 had AD. Moreover, 5 patients tested positive to Fx5 and 16 to Phadiatop.

Microbiological assessment

Samples were taken from all patients before UVB therapy commenced, after 4 weeks of UVB radiation, and after 2 weeks follow up. Sampling was carried out 30 min after each UVB irradiation session, and in AD patient this meant taking samples from lesional skin of the left flexural elbow, forehead and non-lesional skin (i.e. skin not displaying eczema or dermatitis). In healthy controls samples were taken from the left flexural elbow and the forehead.

The sampling technique by Williamson & Kligman (9) was used with some modifications. A sterile glass cylinder (internal area 5.3 cm^2) was held on the skin with moderate

pressure from two fingers and filled with 1 ml of 0.1% Triton x-100 in 0.075 M phosphate buffered saline, pH 7.9. The skin was gently rubbed for one minute with a disposable $10 \mu\text{l}$ inoculating loop (Nunc 251586) before the liquid was removed using a sterile Pasteur pipette. The samples were diluted tenfold and inoculated onto a blood agar medium. The dishes were incubated at 37°C and examined after two days. The bacterial colonies with different morphology were counted (colony-forming units= cfu/cm^2) and identified as two bacterial species, i.e. *S. aureus* and *S. epidermidis* (9).

Phototherapy

The treatment was performed in a Waldmann 8001K cabin with F85/100 W – UV21 tubes. The whole body UVB irradiation was given five times a week for 4 weeks (20 treatments). The UVB initial dose of $0.02\text{--}0.03 \text{ J}/\text{cm}^2$ was gradually increased, depending on the skin type, up to a maximum of $0.20 \text{ J}/\text{cm}^2$. The accumulated mean doses of UVB were $1.68 \pm 0.44 \text{ J}/\text{cm}^2$. All the patients and the healthy controls had skin type II (always burns, sometimes tans) or III (sometimes burns, always tans).

Statistical methods

Bacteria counts were log transformed to normalise the data. Differences in log transformed values of bacteria counts between cases and controls over time was analysed using a generalized linear model implemented in the mixed procedure in SAS version 9. Time was treated as a categorical variable in three categories and implemented in the model as two indicator variables using

before treatment as the reference group. Dependence between repeated observations over three time points were controlled for by specifying an unstructured within subject covariance matrix. Interactions between the variable case (yes/no) and time were added as two product terms, one for each indicator variable of time. Two-sided p-values <0.05 were considered statistically significant (10).

RESULTS

The incidence of *S. aureus* and *S. epidermidis* is presented in Table I. Prior to treatment 16 of the 20 patients had *S. aureus* in lesional skin and on the forehead, while 12 patients had *S. aureus* in non-lesional skin. After 4 weeks of UVB irradiation 14 patients had *S. aureus* in lesional skin, 13 on the forehead and 9 in non-lesional skin. 2 weeks after the treatment was complete (6 weeks from the start of the trial), *S. aureus* was found in lesional skin in 18 patients, on the forehead of 15 and in non-lesional skin in 10. None of the healthy controls had *S. aureus* in samples from the left flexural elbow. Only a few cfu/ml of *S. aureus* were found on the forehead of 2 healthy controls prior to UVB irradiation; this dropped to 1 following completed treatment (Table I).

The mean SCORAD value was reduced from 64.3 to 35.0 ($p < 0.001$) after 4 weeks of UVB treatment. However, after 2 weeks follow up the SCORAD value had increased marginally (44.3; $p < 0.001$). 11 of the 13 patients with more than 10000 cfu/cm² of *S. aureus* in lesional skin before treatment

had a SCORAD value of more than 60. We could not, however, find any association between reduced SCORAD value during the UVB therapy and cfu/cm² of *S. aureus*.

The bacteria counts were log transformed to normalize the data and the results are given in Tables II and III. The *Staphylococcus aureus* counts in lesional skin decreased (not significant) after 4 weeks of treatment. Moreover, *S. aureus* counts in lesional skin were slightly higher after 2 weeks follow up (Table II).

Staphylococcus aureus counts on the forehead (not significant) were reduced after 4 weeks of UVB treatment, but after 2 weeks follow up, the cfu/cm² was even higher than before treatment commenced (Table II). In non-lesional skin the cfu/cm² of *S. aureus* was more or less unaffected following UVB therapy (Table II). Approximately the same mean counts of *S. aureus* and *S. epidermidis* were observed in lesional skin.

No significant variations of *S. epidermidis* were found in lesional skin of AD patients. However, a significantly increased level of *S. epidermidis* was seen on the forehead and in non lesional skin of the patient group, i.e. the level increased steadily from pre-treatment levels through the 4 weeks of UVB irradiation until the end of the 2 weeks following up (table 3). In the healthy controls, no significant change was found in the bacterial count from the two sites before and after UVB therapy (Table III).

Interestingly, significantly lower cfu/cm² of *S. epidermidis* was seen in controls than in the patient group in non-lesional skin (healthy skin) at the time of sampling (Table III).

Table I. The incidence of *Staphylococcus aureus* (*S. aureus*) and *Staphylococcus epidermidis* (*S. epidermidis*) in the three samples areas in patients with atopic dermatitis (n=20) and non-atopic controls(n=20) treated 4 weeks with UVB light therapy (before treatment, after 4 weeks treatment and after 2 weeks follow up).

	Lesional skin			Forehead			Non-lesional skin		
	Before treatment	After 4 weeks	2 weeks follow up	Before treatment	After 4 weeks	2 weeks follow up	Before treatment	After 4 weeks	2 weeks follow up
Patients									
<i>S. aureus</i>	16	14	18	16	13	15	12	9	10
<i>S. epidermidis</i>	19	20	19	20	20	20	20	19	20
Non atopic controls									
<i>S. aureus</i>				2	1	1	0	0	0
<i>S. epidermidis</i>				20	20	20	19	17	18

Table II. *Staphylococcus aureus* count in patients with atopic dermatitis treated 4 weeks with UVB light therapy.

	Lesional skin		Forehead		Non-lesional skin	
Before treatment	7.69	(2.88) ^a	6.51	(3.05) ^a	3.94	(1.75) ^a
After 4 weeks treatment	6.18	(2.98) ^a	5.21	(2.90) ^a	3.35	(1.71) ^a
After 2 weeks follow up	6.22	(2.75) ^a	6.66	(3.02) ^a	4.27	(2.64) ^a
P-value before treatment vs. after 4 weeks	0.066		0.096		0.29	
P-value before treatment vs. 2 weeks follow up	0.048		0.86		0.52	
P-value, overall time difference	0.12		0.027		0.33	

^aValues are mean (standard deviation) on log (value +10) transformed

Table III. *Staphylococcus epidermidis* count in patients with atopic dermatitis and non-atopic controls treated 4 weeks with UVB therapy.

	Lesional skin		Forehead		Non-lesional skin	
Patients						
Before treatment	7.69	(2.53) ^a	8.25	(1.75) ^a	5.44	(1.67) ^a
After 4 weeks treatment	7.92	(1.73) ^a	8.04	(1.69) ^a	6.33	(2.06) ^a
After 2 weeks follow up	7.86	(1.94) ^a	9.00	(0.69) ^a	6.92	(2.06) ^a
P-value, time difference	0.91		0.003		0.002	
Non-atopic controls						
Before treatment			7.79	(2.15) ^a	4.68	(1.78) ^a
After 4 weeks treatment			7.36	(2.06) ^a	3.82	(1.53) ^a
After 2 weeks follow up			7.76	(1.88) ^a	3.98	(1.50) ^a
P-value, time difference			0.21		0.07	
P-value, test of interaction ^b			0.11		0.001	
P-value, group difference ^c			0.008		0.001	

^aValues are mean (standard deviation) on log (value +10) transformed.

^bInteraction between patients and non-atopic controls.

^cOverall difference between patients and non-atopic controls

DISCUSSION

This study demonstrated that UVB has anti-microbial effects against *S. aureus* in patients with atopic dermatitis, which is in accordance with results from previous reports (11).

Furthermore, *S. aureus* occurred frequently in both lesional and non-lesional skin of these patients, which has also been previously reported (11). On the other hand, *S. aureus* was rare in healthy controls. Thus, *S. aureus* appears to be insignificant in the normal cutaneous flora in healthy controls, apart from its existence in the nose and perineum (12,13). Interestingly, not all AD patients had *S. aureus* in non-lesional (healthy skin), and the mean density was only half of that found in lesional skin. Furthermore, the anti-staphylococcal, as well as the clinical effect, was highest immediately after irradiation. In fact, after 2 weeks follow up, *S. aureus* counts in non-lesional skin were even higher than before treatment commenced. *Staphylococcus aureus* occurred in non-lesional (healthy skin) in 60% of the AD patients. These results have been confirmed in other studies (11,14). In a previous investigation, UV radiation was observed to have significant effect on *S. aureus* in AD patients (11), and in the present investigation this was confirmed by a reduction, although not significant, in *S. aureus* counts following UV irradiation.

Staphylococcus aureus appears to be a dominant environmental factor in AD. Hence, eradication of the bacteria in the acute state, and elimination of the re-colonization of *S. aureus* may be a crucial factor in controlling the disease (15,16).

There is now considerable evidence that colonization with *S. aureus* is an exacerbating factor in AD because of the production of super anti-

genic toxins (16,17). This can trigger the release of pro-inflammatory cytokines and depletion of Langerhans cells, leading to migration into regional lymph nodes, where they may activate and enhance the re-circulation of T-cells back into the skin. Furthermore, AD patients may also develop an IgE response to super antigens and thus release histamine from mast cells and basophiles (17).

The study showed a significant clinical improvement of SCORAD after completing UVB therapy, confirming the benefits of UV therapy previously found in patients with AD (18-20). This type of treatment is a very simple, cost effective and safe way of treating skin diseases (20,21).

The effect of UVB on total bacterial densities was found to be marginal since the total counts were mainly dominated by *S. epidermidis*. UVB therapy appeared to have no effect on this bacterium. In fact, *S. epidermidis* is mainly found in skin hair follicles, while *S. aureus* is found on the skin surface (22), making the latter readily accessible for UV radiation (11).

Killing of bacteria using either topical or systemic anti-staphylococcal antibiotics has proved effective in the treatment of AD. Additionally, the combination of a topical corticosteroid and a topical antibiotic has been favourable in patients with impetiginised AD due to healing of the skin, which impairs the attachment of *S. aureus* (2,16), and hence the eradication of germs, *S. aureus* in particular, is beneficial to AD patients.

The population in Tromsø are living in an arctic area. Consideration must be given to how the indoor and outdoor environments elicit symptoms of eczema and allergy. Due to the cold climate of the arctic area, the buildings, in an effort to save energy, generally have an effi-

cient insulation. Poor indoor ventilation and cold outdoor climate may both act as contributing factors in patients with AD, and thus influence the prevalence and the morphology of AD (3).

In conclusion, *S. aureus* is widely colonised in skin of AD patients, but uncommon in healthy adults. UVB radiation appears to decrease the *S. aureus* count in skin of AD patients.

REFERENCES

1. Haagerup A, Bjerke T, Schiøtz PO, Dahl R, Binderup HG, Tan Q et al. Atopic dermatitis – a total genome-scan for susceptibility genes. *Acta Derm Venereol* (Stockh) 2004;84:346-352.
2. Thestrup-Pedersen K. Atopic eczema – new insights in the definition, diagnostics and disease management. *Acta Derm Venereol* (Stockh) 2005;Suppl 215:1-48.
3. Dotterud LK, Odland JØ, Falk ES. Atopic dermatitis and respiratory symptoms in Russian and northern Norwegian school children: a comparison study in two arctic areas and the impact of environmental factors. *J Eur Acad Dermatol Venereol* 2004;18(2):131-136.
4. Dahl MV. Staphylococcus aureus and atopic dermatitis. *Arch Dermatol* 1983;119:840-846.
5. McFadden JP, Noble WC, Camp RDR. Superantigenic exotoxin secreting potential of staphylococci isolated from atopic eczematous skin. *Br J Dermatol* 1993;128:631-632.
6. Strange P, Lone S, Lisby S, Nielsen PL, Baadsgaard O. Staphylococcal enterotoxin B applied to intact normal and intact atopic skin induced dermatitis. *Arch Dermatol* 1996;132:27-33.
7. Hanifin JM, Rajka G. Diagnostic features of atopic dermatitis. *Acta Derm Venereol* 1980;Suppl 92:44-47.
8. Severity scoring of atopic dermatitis: the SCORAD index. Consensus Report of the European Task Force on Atopic Dermatitis. *Dermatology* 1993;186:23-31.
9. Williamson P, Kligman A. A new method for the quantitative investigation of cutaneous bacteria. *J Invest Dermatol* 1965;45:498-503.
10. SAS Institute SAS/STAT Guide for Personal Computers. Cary, NC: (USA): SAS Institute, 1992.
11. Jekler J, Bergbrant JM, Faergemann J, Larkø O. The in vivo effect of UVB radiation on skin bacteria in patients with atopic dermatitis. *Acta Derm Venereol* (Stockh) 1992;72:33-36.
12. Lever R, Hadley K, Downey D, Mackie R. Staphylococcal colonization in atopic dermatitis and the effect of topical mupirocin therapy. *Br J Dermatol* 1988;119:189-198.
13. Masenga J, Garbe C, Wagner J, Orfanos ES. Staphylococcus aureus in atopic dermatitis and in non-atopic dermatitis. *Int J Dermatol* 1990;29:579-582.
14. Hauser C, Wüthrich B, Matter L, Wilhelm JA, Schopfer K. Immune response to Staphylococcus aureus in atopic dermatitis. *Dermatologica* 1985;170:114-120.
15. Ripple F, Schreiner V, Doering T, Maibach HI. Stratum corneum pH in atopic dermatitis: impact on skin barrier function and colonization with Staphylococcus aureus. *Am J Clin Dermatol* 2004;5:217-223.
16. Leung DY. Infection in atopic dermatitis. *Curr Opin Pediatr* 2003;15:399-404.
17. Leung D. Superantigens, steroid insensitivity and innate immunity in atopic eczema. *Acta Derm Venereol* 2005;Suppl 215:11-15.
18. Faergemann J, Larkø O. The effect of UV-light on human skin micro-organisms. *Acta Derm Venereol* (Stockh) 1987;67:69-72.
19. Reynolds N, Franklin V, Gray J, Diffey B, Farr P. Narrow-band ultraviolet B and broad-band ultraviolet A phototherapy in adult atopic eczema: a randomised controlled trial. *Lancet* 2001;357:2012-2016.
20. Falk ES. UV-light therapies in atopic dermatitis. *Photodermatol* 1985;2:241-246.
21. Weischer M, Blum A, Eberhard F, Röcken M, Bernerburg M. No evidence for increased skin cancer risk in psoriasis patients treated with broadband or narrow-band UVB phototherapy: a first retrospective study. *Acta Derm Venereol* (Stockh) 2004;84:370-374.
22. Noble WC. The role of the staphylococci in dermatology. *J Eur Acad Dermatol Venereol* 1996;Suppl 1:12-14.

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