

CHRONIC POLYMORPHIC LIGHT ERUPTION

Particular Wavebands and the Effect of Carotene Therapy

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Abstract. Forty patients with chronic polymorphic light eruption (CPLE) were tested with the Osram High Pressure Xenon (XBO 150 W) lamp. The tests were performed with unfiltered light, with the Schott WG320 filter for wavelengths above 320 nm and with Schott filters for 310 nm and 361 nm. Abnormal reactions, i.e. lowered MED, papular response or reactions to long wave UV light were observed in almost all patients. A papular response was obtained in more than 50%. With a Schott KG1 filter, which particularly reduces the amount of infrared radiation, there was a great reduction in number of responses. The effect of carotene therapy was evaluated in 17 patients. The therapy had a beneficial effect of low significance only in the case of unfiltered light and not for any particular waveband. Some patients showed clearly an increase in tolerance to sunlight, but this was not related to the plasma level of carotene.

Key words: Photodermatosis; Polymorphic light eruption; Wavebands; Carotene

It is generally agreed that the responsible action spectrum in chronic polymorphic light eruption (CPLE) is not only confined to the sunburn range (290-320 nm) but sometimes also to long ultraviolet (UV) light (320-400 nm) and the visible part of the spectrum (above 400 nm). There are, however, conflicting views as to the specificity of certain spectral wavebands in producing cutaneous changes (1, 3, 4, 9, 13).

Because wavelengths outside the sunburn range also can produce skin lesions, commonly applied sunscreens are of no great value. Treatment with antimalarials is generally effective but severe side effects may occur during long-term treatment. The same also applies to the use of strong topical corticosteroids. Lately, therapy with carotenoids has been tried in CPLE (5, 8, 10, 11). The reports indicate that some effect is to be ex-

pected, though a more critical evaluation of a larger group of patients would seem justified.

The purpose of the present study was to investigate 1) the effect of some particular spectral wavebands in CPLE, 2) the therapeutic effect of carotenoids, and 3) whether this effect—if any—could be related to any particular wavebands.

MATERIALS AND METHODS

A total of 40 patients aged 10 to 63 years (23 females, 17 males) suffering from CPLE were investigated. The clinical diagnosis of CPLE was established according to the usual criteria (1, 6). Patients with prurigo atopicum and Hutchinson's summer prurigo were not included. Five patients had a family history of light sensitivity and CPLE was present in one of the children or parents. Two patients had CPLE and solar urticaria. In 7 patients the symptoms had started before the age of ten, in 10 patients between the age of ten and twenty, in 17 patients between the age of twenty and fifty and in 6 patients after the age of fifty years. The duration of symptoms varied from 2 to 20 years.

Several sunscreens such as *p*-amino-benzoic acid (PABA) in glycerol and 70% alcohol, 10% sulizobenzene (2-hydroxy-4-methoxy-benzophenone-5-sulphonic acid (Uval) and dihydroxyacetone/lawsone had been tried by many patients without apparent benefit.

The phototests were performed with an Osram High Pressure Xenon Arch Lamp (XBO 150 W). The radiation output was measured at each test procedure with a Hewlett & Packard Radiant Flux Meter. The phototesting procedures were carried out with unfiltered light (mean output 210 mW/sec/cm²), with Schott filters for (a) 310 nm (mean output 5mW/sec/cm², half bandwidth 305-315 nm), (b) 361 nm (mean output 12mW/sec/cm², half bandwidth 340-380 nm), (c) wavelengths above 320 nm (filter WG 320 nm) (mean output 190 mW/sec/cm²) (d) wavelengths mainly between 300 and 700 nm (KG1 filter) and (e) the KG1+WG 320 filter combination. The transmission characteristics are illustrated in Fig. 1. The chosen exposure times were based on normal controls and included both an exposure dose with no erythematous response and

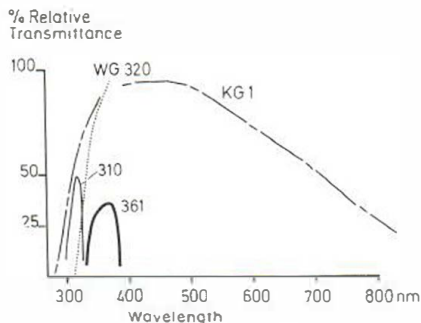


Fig. 1. Spectral irradiance of the xenon arc lamp equipped with KG1 and WG 320 filters and filters for the 310 nm and 361 nm wavebands.

an exposure dose producing minimal perceptible erythema (MED). The reactions were read at 8, 24, and 48 hours after irradiation and the exposures were expressed as mJ/cm^2 or J/cm^2 .

The susceptibility to a papular reaction (PR) was investigated by exposure to 3–6 times the MED. The lowest dose producing this reaction was expressed as the papular reaction dose (PRD). Unexposed skin, i.e. the back and in some instances the upper arm, was used as test site. Twenty-one healthy subjects served as controls. All subjects were tested at least twice.

Carotene therapy. Seventeen patients were given beta-carotene tablets containing canthaxanthine (1 tablet \approx 25 mg carotene) in doses of 3–4 tablets daily. The carotene plasma level was determined before the therapy started, after 3–4 weeks of therapy and later on after 2–3 months. On the same occasions phototests were performed and the patient's threshold tolerance to sunlight (TTS) was noted.

RESULTS

Controls. Fig. 2 shows the results obtained in 21 normal subjects. With the 310 nm waveband the MED was in the region between 0.05 and 0.1 J (one subject was not tested). With unfiltered light the MED was between 0.9 and 2 J in 14, while 4 sub-

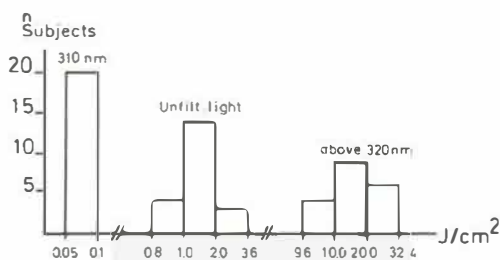


Fig. 2. Relationships between MED and number of normal subjects tested with the 310 nm waveband, unfiltered xenon light and wavelengths above 320 nm.

Table I. Minimum erythema dose (MED) and papular reaction dose (PRD) with unfiltered light and with filtered light >320 nm (WG 320), at 310 nm and at 361 nm in CPLE

		Number	
		MED	PRD
Unfiltered light (n subjects tested=40)	0.27–0.9 J/cm^2	12	1
	1.0–1.9	12	1
	2.0–2.9	5	4
	3.0–4.0	5	11
	5.0–5.9	3	5
WG 320 (n subjects tested=40)	2.6– 5.9 J/cm^2	4	1
	6.0– 9.9	6	1
	10.0–13.9	12	5
	14.0–17.9	9	0
	18.0–20.0	1	0
361 nm (n subjects tested=32)	0.7– 1.9 J/cm^2	3	0
	2.0– 2.9	11	4
	3.0– 3.9	2	0
	4.0– 4.9	3	2
	5.0– 5.9	3	3
310 nm (n subjects tested=32)	5– 25 mJ/cm^2	13	1
	30– 55	9	2
	60– 85	1	4
	90–115	3	7
	120–150	2	4

jects had a lower (0.8–0.9 J) and 3 a higher MED (2.0–3.6 J). As can be seen from Fig. 2, large variations in MED were observed with the WG 320 nm filtered radiation (i.e. between 9.6 and 32.4 J). Two subjects had no response with irradiations up to 32.4 J. No papular response was observed among the control subjects tested so far.

Patients. Wide interindividual variations in responses ranging with a factor of 10 between the least and most sensitive patients were observed. Repeated tests before therapy also showed individual variations with a factor of 2–3, particularly with unfiltered light, and less with the filtered wavebands. Table I shows the results obtained with unfiltered light, with WG 320 filtered radiation and with the 361 and 310 nm wavebands.

With unfiltered light the MED could be determined in 37 patients, while 3 showed only a PR (at 0.8 J, 2 J and 5.5 J). The last two of these had an urticarial response. Twelve patients had an increased sensitivity to unfiltered light, with a MED below 0.9 J. In another 22 patients the MED was within or slightly above the MED range for normal subjects. A PR was observed in 22 patients (12 females and 10 males). In 17 the PRD approximated

Table II. Effect of carotene therapy on minimum erythema dose (MED) induced by different wavelengths in 17 patients with CPLE (mean values)

N.T.=not tested

Patient	MED (J/cm ²)							
	Before therapy				During therapy			
	Unfilt. ^a	310 nm	320 nm	361 nm	Unfilt. ^a	310 nm	320 nm	320 nm
KE	1.0	0.140	13.0	3.6	5.15	0.055	17.1	5.04
EE	0.63	0.055	12.0	2.88	1.0	0.085	13.0	2.0
KH	0.8	0.165	2.6	0.72	3.0	0.030	2.55	1.98
BH	2.1	0.025	14.25	1.98	4.38	0.150	18.0	5.04
VH	3.15	0.050	17.1	4.62	2.0	0.100	18.0	5.04
TH	1.03	0.083	17.1	2.8	3.5	0.850	17.1	3.6
FH	2.0	0.050	15.0	2.16	4.0	0.100	17.1	1.8
RK	0.4	0.010	8.0	2.16	5.0	0.025	10.0	5.04
JK	1.0	0.025	11.55	2.64	4.3	0.055	17.1	5.04
TL	4.3	0.055	13.3	2.16	4.3	0.075	13.3	2.16
KI.	3.0	0.025	14.25	2.16	1.0	0.025	13.3	2.16
ÅM	1.0	0.025	11.2	2.6	2.1	0.025	13.0	4.44
DS	0.8	0.150	10.4	4.3	0.4	0.055	10.8	4.3
AS	4.05	0.025	12.0	4.3	1.0	0.055	12.9	2.16
ES	3.2	0.100	13.3	5.3	1.0	0.025	17.1	5.04
GS	0.8	N.T.	6.4	4.6	0.4	0.025	15.6	4.6
MS	2.1	0.750	17.24	2.95	5.0	0.055	17.7	2.64

^a Unfiltered light.

the dose required to produce minimal erythema in normal subjects. In 5 patients the PRD was much higher.

With wavelengths above 320 nm the MED recorded in 32 patients was actually within the range found in normal subjects. A PR was recorded in 7 patients with wavelengths above 320 nm. One patient was extremely sensitive to these wavelengths and showed a papular response at 2.6 J, while another reacted at 7.2 J. Eight patients showed no reactions at all to the WG 320 filtered radiation with doses up to 20 J.

Thirty-two patients were phototested with filtered radiation at 310 and 361 wavebands. The MED was determined in 28 patients with the 310 waveband. In 26 patients it was within or just above the MED values observed in normal subjects. As many as 18 patients developed a PR. In one of them the dose was as little as 5 mJ while in the others the PRD was between 30 and 150 mJ, i.e. about the MED values for normal subjects.

With the 361 nm waveband a MED could be determined in 22/32 patients. In 14 the MED was below 2.9 J, while in the other patients it was between 3 and 5.9 J. A PR was observed in 9 patients, i.e. between 2 and 2.9 J in 4 and between 4 and 5.9 J in another 5 patients.

Forty patients were tested with the KG1 and KG1+WG 320 filter combination. With the KG1 filtered radiation with an erythema to doses below 10 J a PR was observed in 4 patients between 1.4 and 10 J. One of these patients had PR at 1.8 J. Seven patients reacted to the KG1+WG 320 filtered radiation with an erythema to doses between 1.2 and 19.2 J. Three of these patients had also a PR at 5.4, 12.0 and 19.2 J.

Summing up, a PR was observed in 22/40 patients, but it appeared that the susceptibility to develop a PR to the different wavebands varied both individually and interindividually. Thus it was not the same subjects who constantly developed papular responses and one subject could react with a PR to one waveband and showed only faint erythema to another.

One patient had only normal or no responses at all to the different wavebands used in these phototests. This was a boy aged 6 years who clinically only developed papular lesions after prolonged sunlight exposure on several consecutive days. Eight patients developed a PR to all the wavebands tested except to the KG1 filtered radiation. Five patients had pathological reactions to only unfiltered, while 3 reacted to both unfiltered and WG 320 filtered radiation. In the remaining patients a

Table III. Effect of carotene therapy on the papular reaction dose induced by different wavelengths in 13 patients with CPLE (mean values)

Patient	Dose of papular reaction (J/cm ²)							
	Before therapy				During therapy			
	Unfilt. ^a	310 nm	320 nm	360 nm	Unfilt. ^a	310 nm	3210 nm	361 nm
KE	5.0	0.025	17.1	3.6	5.0	0.110	17.1	3.6
EE	5.0	0.082	12.0	5.04	3.5	0.025	13.0	5.04
KH	3.2	0.028	2.6	4.5	0.8	0.028	13.3	2.0
TH	5.0	0.050	17.1	2.88	3.0	0.050	17.1	5.0
FH	5.0	0.100	17.1	2.88	5.0	0.125	17.1	5.0
RK	0.8	0.010	11.2	4.32	5.0	0.060	17.1	5.0
JK	5.0	0.075	11.55	5.04	5.0	0.100	17.1	5.0
KL	3.0	0.075	17.1	5.00	2.0	0.025	17.1	5.0
ÅM	4.0	0.100	17.1	5.00	1.0	0.075	17.1	4.62
DS	4.4	0.100	7.2	4.32	2.0	0.100	12.4	4.3
ES	5.0	0.150	20.9	5.30	5.0	0.150	20.9	5.3
GS	2.4	0.100	20.9	5.04	3.0	0.075	20.9	5.04
MS	4.0	0.100	17.1	5.04	5.0	0.055	20.9	5.04

^a Unfiltered light.

lowered MED and/or PR was observed to one or more wavebands.

Effect of carotene therapy. This was evaluated in 17 patients, of whom 13 had a papular response to one or more wavebands. The mean values of the MED and the PRD for the different wavebands tested before and during the therapy, are shown in Tables II and III. The influence of the therapy on the MED and the PRD is illustrated in Table IV. It appeared that the therapy did not have an equal effect on the different wavebands. This concerned both the MED and the PRD. For instance the patients KE and KH showed a decrease in MED at 310 nm, while it increased at the other wavebands. During the therapy, patient KH showed a decrease in PRD for unfiltered light, an increase in PRD at wavelengths above 320 nm but a decrease at the 361 nm waveband. The PRD at 310 nm remained unchanged, however.

During the therapy an increase in MED was particularly observed towards unfiltered and long UV light (Table IV), while the PRD was less frequently increased. In several patients, however, the MED and/or the PRD could not be exactly determined because the tests were too time-consuming or the patient could not be traced for control. In these cases only the largest dose not inducing erythema or papular response was noted. From Table II the change in MED (i.e. protecting factor, PR) for the different wavebands tested, can be calculated; unfiltered light: 1.8; 310 nm: 1.3; above 320 nm: 1.1; 361 nm: 0.9. The corresponding values for the PRD were: unfiltered light: 0.4; 310 nm: 0.6; above 320 nm: 1.4; 361 nm: 0.7. It has to be taken into consideration that the calculated values are not exact due to the facts mentioned above.

Table V shows the types of lesions, TTS (before and during therapy), PF towards sunlight, i.e., the

Table IV. Influence of carotene therapy on the MED and PRD in relation to various wavelengths

Threshold	Number of patients							
	MED				PDR			
	Unfilt. ^a	310 nm	320 nm	360 nm	Unfilt. ^a	310 nm	320 nm	360 nm
Increase	11	9	13	10	5	4	3	4
Lowered	6	5	1	3	5	5	0	1
Unaltered	0	3	3	4	3	4	10	8
Total	17	17	17	17	13	13	13	13

^a Unfiltered light.

Table V. Types of lesions, mean plasma carotene values, threshold of tolerance to sunlight (TTS) and protective factor (PF) in 17 patients with CPLE

Patient	Type of lesion	TTS (min)		PF	Plasma carotene mean values ($\mu\text{g}\%$)
		Before therapy	During therapy		
KE	Plaque	60	60	1	525
EE	Eczema	10	240	24	715
KH	Papular	10	120	12	1 210
BH	Plaque	10	10	1	280
YH	Papular	5	40	8	1 100
TH	Papular	5	120	24	760
FH	Eczema	10	60	6	1 095
RK	Eczema	10	120	12	1 160
JK	Eczema	20	120	6	1 250
TL	Plaque	10	20	2	1 170
KL	Papular	20	120	6	1 250
ÅM	Papular	5	30	6	2 100
DS	Urtica ^a	5	20	4	1 180
AS	Eczema	15	240	16	1 365
ES	Papular	5	5	1	885
GS	Papular	10	300	30	1 140
MS	Eczema	5	120	24	950

^a Eczema

ratio between the TTS before and during the therapy, and the mean values of the plasma carotene in the 17 patients treated with carotenoids. Seven patients showed an increase in PF of more than 10 (range 12–30). The patient EE was working as a keeper at a larger light house on the south coast and could barely stay outdoors for more than 10 minutes without developing severe symptoms later on. He had considered giving up his profession before starting with the therapy. While on carotene, it was his first summer in many years that he could stay out in the sunshine for several hours without complaining. The MED in this patient was not greatly altered; at 361 nm it was even lowered. His PRD did in fact decrease for unfiltered light and at 310 nm. With wavelengths above 320 nm there was a slight increase in PRD during the therapy.

This variance in MED, PRD and PF towards sunlight was also observed in other patients, as for instance in KE, who showed an increase in MED for all wavelengths except 310 nm while a papular response was only observed during treatment, and then at 310 nm. The PF towards sunlight was unaltered in this patient. The patient ES, who also had an unaltered PF towards sunlight, showed a decrease in MED for unfiltered light and at 310 nm. In the same patient the PRD increased markedly for wavelengths above 320 nm and for 361 nm, and in fact no papular reactions could be induced during the treatment.

Statistical evaluation. The therapy with carotenoids caused a significant increase in MED for unfiltered light at the 5% level of probability (Mann-Whitney O-test). However, no significant difference ($P > 0.1\%$) in MED was observed for the particular wavebands, or in PRD at any waveband. Despite a larger increase in TTS in some patients, the PF was not significantly altered and the correlation factor between PF towards sunlight and plasma carotene level was almost zero ($r = -0.037$). Neither could the increase in MED towards unfiltered xenon lamp radiation be correlated with the plasma carotene level ($r = -0.289$).

Side effects. In this study there were no serious side effects which could be ascribed to carotene. Two female patients noted a tendency to irregular menstruation periods and almost all patients got a slight yellow brown pigmentation, particularly on the palms and soles and to a lesser degree also in the face. One patient complained of nausea and a tendency to vomit. All these side effects subsided after the therapy was stopped and did not influence the duration of treatment.

DISCUSSION

Several patients showed an MED in the normal range or even above, thus confirming the results obtained in other studies (3, 4, 6, 14). But in some very sensitive patients a papular response was pro-

duced by very low doses which in fact corresponded to the lowest MEDs in normal subjects. To sum up, there were abnormal reactions, i.e. lowered MEDs, papular responses or reactions to long UV light in almost all patients. With unfiltered light an increased sensitivity was observed in about 50%, and it is possible that a more cumulative effect towards repeated exposures is necessary in many of the other cases in order to produce a pathological response. The large amount of energy which is emitted in the infrared part of the spectrum by the xenon arc lamp, is a possible explanation of the large dose measured with unfiltered and the WG 320 filtered radiation.

The high susceptibility to the 310 and the 361 nm wavebands accords with the findings of others (3, 4) while the tests performed with the KG1 and KG1+WG 320 filters induced surprisingly few reactions despite test doses as high as 2.6 J and 16.8 J, respectively. The KG1 filter transmits radiation in the region of about 300 to 650 nm in particular, and reduces the infrared part of the xenon lamp radiation markedly. According to Epstein (1) and others (9) any wavelength is of importance in producing lesions in CPLE and this may in part explain the great reduction in number of reactions which occurred with the KG 1 filter, which cuts off the additive effect of longer wavelengths (12, 14) and to some extent a part of the UV radiation. On the other hand, regarding the frequent reactions caused by the 361 nm and 310 nm wavebands, a special susceptibility to selected wavelengths must be taken into consideration. In the present investigation 22/32 patients reacted to the 361 nm waveband, whereas Frain-Bell et al. (3), in a recent study with the grating monochromator, observed abnormal reactions to different wavebands with long UV and even invisible light up to 500 nm, in 25% of their patients.

Effect of carotene therapy. Statistically speaking, this therapy had a beneficial effect of low significance only, as regards unfiltered light. An increase in MED of sunburn radiation in normal subjects has been observed by Mathews-Roth et al. (7) and a moderate correlation between the increase in MED and the plasma carotene level was described by Swanbeck & Wennersten (10) in their tests with unfiltered xenon radiation. In the present study the mean PF, i.e. increase in MED, for unfiltered light was about 1.8. A statistically significant increase in TTS was not observed in several patients, despite a

large PF. The increase in TTS noted in these patients could not, however, be related to the plasma carotene level. Neither was there any correlation between the increase in MED to unfiltered light and the plasma carotene.

Recently, Nordlund et al. (8) described a patient with CPLE who was sensitive to light in the 290 to 500 nm range and whose symptoms were ameliorated by a combined therapy with sulizobenzone and beta-carotene. A similar effect has been observed by the present author using PABA 5% in glycerine and spir. dilut. combined with carotene (unpublished). Yet many patients did not improve even on this therapy. Thus for the time being there seem to be some patients who benefit from carotene, while others do not. A prophylactic effect of beta-carotene against the additive effect of long UV on the short UV light (12, 14) is a possibility, but other mechanisms may also be relevant, presumably on the biochemical level by quenching of singlet oxygen molecules (2, 11) analogous the action in some types of porphyria. Different types of CPLE with different reaction patterns might offer another explanation, as some patients undoubtedly benefit from carotene therapy.

ACKNOWLEDGEMENTS

Professor I. A. Magnus, London, is thanked for valuable discussions.

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Received May 20, 1975

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