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ERYTHEMA DIFFERENCES BETWEEN THE CRANIAL AND CAUDAL PARASTERNAL REGIONS AT 12 MeV ELECTRON IRRADIATION

by

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Following irradiation of the parasternal region, radiation erythema is often more noticeable in the cranial than in the caudal part of this area, even though the treatment of the two areas has been identical (Fig. 1).

It has been suggested that the increased sensitivity to ionizing irradiation of the skin on the neck and upper part of the thorax may be attributed to various causes, such as prolonged sensitizing of the skin through exposure to light, differences in the pigmentation of the skin, or various degrees of secondary irradiation of the skin due to variations in the underlying bone tissue. However, the same difference in erythema at the level of the second intercostal space is also seen during spontaneous blushing or after rubbing of the skin. The reddening spreads over the face, the neck and a V-shaped area on the upper part of the thorax but not as a rule below the second intercostal space (Fig 2). This limitation is due to a varying sympathetic innervation of the skin at the cervico-thoracic level.

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Table 1

Ratio between patients with more extensive radiation erythema at points a_1 and a_2, as compared with point b_2, and total number of patients measured

Significance	Before irradiation	After 5th irrad.	After 10th irrad.	14 days after last irrad.	28 days after last irrad.
p = 0.1 %	12/13	14/16	15/16	14/16	9/16

Table 2

Ratio between patients with more extensive radiation erythema at point b_1, as compared with point b_2, and total number of patients measured

Significance	Before irradiation	After 5th irrad.	After 10th irrad.	14 days after last irrad.	28 days after last irrad.
p = 0.1 %	4/13	7/16	7/16	7/16	4/13

Significant difference in dermal erythema at the same level has also been observed by ADAMS-RAY (1952) after irritation of the skin with mustard oil, not only in adults but even in newborns, indicating that the difference in sensibility of the skin is congenital and not a result of environmental conditions such as exposure to light or heat.

The present study has been made to investigate whether the difference in radiation erythema between the cranial and caudal parasternal regions was influenced by the same mechanism and was a constant phenomenon during and after irradiation.

Material and Methods. Sixteen patients with breast cancer were irradiated on the parasternal region after radical mastectomy with 12 MeV electrons from a Siemens 17 MeV betatron and received 10 × 400 R_β in 22 days to 2 fields 6 × 8 cm (Fig. 3) (R_β is a provisional unit, obtained by using the ^{60}Co R-factor for a 100 R Victoreen chamber for the electron beam).

An erythema developed during treatment and reached its maximum about 14 days after the end of the course, after which it diminished.

The differences in skin redness were estimated by measuring the light reflection of the skin in the 550 mμ wavelength range, which includes the typical absorption bands of hemoglobin (PFEIDERER 1960). The measuring probe (a commercial unit from AGA), 8 cm high and 7 cm in diameter, consists of a light source, a filter holder and a selenium photocell; the filter used was of the interference type with a transmission of 500 to 580 mμ (Baltzer's Filtra-

Fig. 1. Erythema following irradiation of the supraclavicular and parasternal areas with 12 MeV electrons. Less erythema in lower part of the parasternal region. The shape of the erythema on the left side was caused by rubbing the skin.

Fig. 2. Spontaneous blushing. Cervicothoracic limitation of the erythema at the level of the second intercostal space, corresponding to the innervation area of C4 and D2.

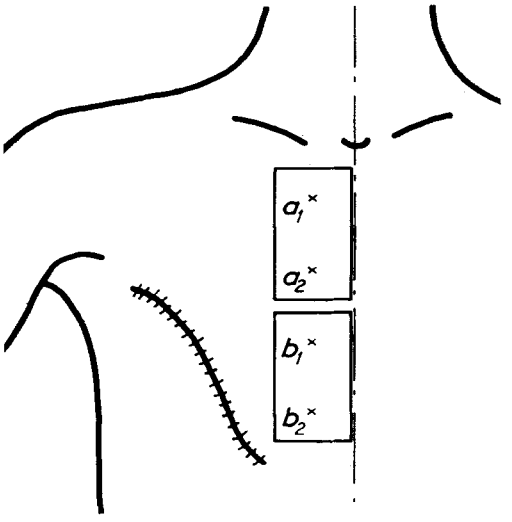

Fig. 3. The two parasternal irradiation fields, and the measuring points $a_{1,2}$ and $b_{1,2}$.

flex K No. 4). The principle in these measurements was that the filtered light beam illuminated an area of skin, 2 cm in diameter, whereupon the reflected light activated the photocell, the current produced being measured with a galvanometer (Kipp type A 70).

The difference in skin redness was calculated from $\frac{I_b - I_a}{I_b} \times 100\ \%$, where I_b and I_a are the currents measured at points b and a, respectively. A positive difference indicates that the redness was more marked at point a than at point b. The differences obtained from photoelectric measurements of this type are very slight, even when the visual differences are quite considerable, and for this reason the voltage supply to the measuring apparatus was stabilized.

The skin redness was measured at all four points in the irradiated areas (Fig. 3) before, in the middle of and at the end of the radiation treatment as well as at 14 and 28 days after treatment. On each occasion, 10 readings were taken for each of the four points, the average standard deviation being 2 %. The statistical significance of the difference of the means between any two points on one and the same patient was estimated with the t-test.

Results

The measurements disclosed no significant differences in skin redness between points a_1 and a_2. These two points have therefore been combined to a mean value for each patient.

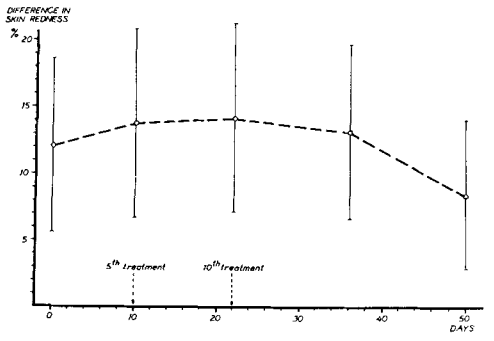

Fig. 4. Mean value of differences between the dermal redness at points $a_{1,2}$ and b_2 for all patients. The bars indicate the standard deviation of the mean. At the last measurements, when pigmentation of skin develops, the curve is sloping.

It is shown in Table 1 that practically all the patients had a significantly stronger redness in the upper field (99.9 % probability), as compared with the lower field-points b_1 and b_2, except for the last measurement 14 days after completing the treatment.

It may be seen from Table 2 that only about half the number of patients also had a significantly stronger redness at point b_1, as compared with b_2. This may depend on point b_1 being located near the 2nd intercostal space, i. e. at the level of the cervico-thoracic junction (Fig. 3).

The mean values of the differences in dermal redness between the upper field and point b_2, for all patients, are given in Fig. 4. The mean differences seem to be approximately constant throughout the period until the last measurement, where the curve is falling. Depending on the individual differences between the patients, the standard deviations of the means are of course large.

Discussion

The difference in dermal redness on the neck, and above the second intercostal space on the one hand, and in the area caudal to this space on the other, is most probably due to dissimilarities in the sympathetic innervation of these two regions. The cranial region corresponds to the innervation field of the upper cervical spine C1—C4 with C4 as the lower limit. The caudal region is innervated from the upper thoracic spine, with D2 as the upper limit; C4 receives its vasoconstrictor impulses via the stellate ganglion and the superior cervical ganglion whereas the lower cervical and upper thoracic segments receive theirs from the stellate ganglion and the middle cervical ganglion. The thoracic spinal segment is held to have a higher sympathetic tonus, causing vasoconstriction and reducing the blood flow. This can explain why the erythema in the caudal region is less marked.

Most of the patients also received irradiation to the supraclavicular area (see Fig. 1). However, comparisons between these and patients without such treatment indicated that no contributory dose from this field influenced the erythema in the parasternal field.

As already mentioned, the mean difference in redness was less on the last measurement, 28 days following the radiation therapy (Fig. 4). A plausible explanation of this is that 15 to 30 days after the end of the irradiation a slight brown pigmentation developed. This started always in the lower field, where the epithelium was less affected than in the upper field. As it is not possible to distinguish exactly between erythema and pigment by means of photometry (TRONNIER 1963) this may have influenced the measurements, causing a higher absorption of light in the lower field, and hence a smaller measured difference between the two fields. Pigmentation was observed visually at the last measurement in four patients, all belonging to the group without difference in redness at the last measurement.

SUMMARY

Report on results of photometric evaluation of dermal erythema in 16 patients with breast cancer by measurements before, during and after irradiation of the parasternal region with 12 MeV electrons, 10×400 R_β in 22 days. The erythema, which is chiefly conditioned by the blood circulation, was throughout the period more marked in the region cranial to the second intercostal space, corresponding to the innervation field of the nerves from the cervical spine, with C4 as the lower limit. The differences in the radiation erythema between the regions cranial and caudal to this thoraco-cervical border were significant on all occasions.

ZUSAMMENFASSUNG

An 16 Patienten mit Brustkrebs wurde das Hauterythem bevor, während und nach der Bestrahlung der parasternalen Region mit 12 MeV Elektronen photometrisch gemessen. Die verabreichte Dosis war 10×400 R_β in 22 Tagen. Das Hauterythem war im kranialen Teil der parasternalen Region, oberhalb des 2 Intercostalraumes, entsprechend dem Innervationsgebiete der Cranialnerven 1—4, deutlich stärker ausgeprägt als im unteren Bereich der parasternalen Region.

RÉSUMÉ

L'érythème cutané après irradiation de la région parasternale par des électrons de 12 MeV a été mesuré photométriquement avant, pendant et après l'irradiation, sur 16 malades atteintes de cancer du sein. La dose administrée était de 10×400 R_β en 22 jours. L'érythème cutané était nettement plus accusé dans la partie supérieure de la région parasternale, au dessus du 2^e espace intercostal, correspondant au territoire des 4 premiers nerfs cervicaux, que dans la partie inférieure de la région parasternale.

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