Technical Papers

The X-Ray Dose-Body Size Relationship in Radiation Sickness

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Since 1949, under the auspices of the Medical Research Council, an investigation has been undertaken into the general effects upon patients of a single therapeutic dose of x-rays. An essential part of this investigation has been the study of the pattern of the symptoms which may be produced by doses of x-rays within the range of integral dose (total energy absorption) of 2½ to 5 megagram-roentgens. A preliminary report (*1*) has shown that the symptom pattern contains three essential phases: the latent period, the period of acute symptoms, and the recovery period, of which the first two only are of importance as far as this communication is concerned. The latent period is defined as the time elapsing from the commencement of irradiation to the onset of symptoms. The onset of symptoms is quite sudden, the two outstanding initial symptoms being nausea and fatigue. By paying repeated visits to the patient, ostensibly for other purposes (e.g., the collection of specimens of blood and urine), it is possible to determine the time of onset of symptoms with considerable accuracy, without influencing the patient by suggestion. To eliminate the possibility that the symptoms were in part psychologically induced by such procedures as being positioned under the x-ray tube, many of the patients were also exposed to sham irradiations; from our experience of the effects of such sham irradiations, we are confident that the symptoms which develop at the end of the latent period are the result of the actual x-irradiation. The period of acute symptoms extends from the time of onset of symptoms to the time when there is clear evidence of an improvement in the condition of the patient, as indicated either by the cessation of vomiting, or by the disappearance of nausea and fatigue when vomiting is absent. Though there is certainly some error in the estimate of the length of this period, our findings indicate that there is a close relationship between the lengths of the two periods, the length of the latent period being inversely proportional to that of the period of acute symptoms.

Previous studies had led us to believe that the length of the latent period was influenced by the integral dose given, tending to be short with high doses and long with low doses. In spite of this belief, a significant correlation was not found between the length of the latent period and the integral dose (*1*); it is now clear that the reason for this was the variation in body size of our patients. The object of this present communication is to report that, if the size of the patient is taken into consideration along with the integral dose, a satisfactory correlation can be obtained with the length of the latent period. As far as the authors are aware, this is the first time in human studies where the size of the individual has been demonstrated to be of importance in considering any biological effect produced by a given dose of x-rays.

Twenty patients, all early cases of ankylosing spondylitis, have been subjected to a single dose of x-rays (Table 1). In each instance the whole of the vertebral column has been irradiated from a point in the midplane 5 cm below the level of the posterior superior iliac spines up to the region of the occipital protuberance. In all 20 patients a field 15 cm × 10 cm in area was used to irradiate the sacroiliac joints, the longer side lying transversely in relation to the line of the vertebral column. In 12 patients the remainder of the length of the column was irradiated by fields 10 cm in width, and in the remaining 8 patients by fields 7 cm in width. Irradiation was given by x-ray tubes energized at 240 kv, the tube current being 18 ma, and the half-value layer of the emergent beam being 1.85 mm Cu. The integral doses were calculated from data obtained by Boag (*2*) and represent the total energy absorbed in the body resulting from both direct and scattered radiations.

TABLE 1

Case No.	Latent period (hr)	Integral dose (megag r)	Weight (kg)	Surface area (m^2)
1	1.5	4.48	46.7	1.35
2	1.75	4.48	62.28	1.73
3	2.00	3.46	51.50	1.57
4	2.50	4.31	63.0	1.80
5	2.50	4.825	57.3	1.68
6	2.75	2.94	50.1	1.50
7	2.75	2.88	62.0	1.72
8	2.75	4.14	54.64	1.62
9	2.75	4.705	73.5	1.85
10	3.00	4.69	63.5	1.75
11	3.00	3.96	61.8	1.76
12	3.00	5.00	70.5	1.83
13	3.00	4.25	48.96	1.46
14	3.50	3.44	68.4	1.85
15	3.75	4.30	57.05	1.70
16	3.75	5.18	63.6	1.98
17	4.25	3.26	68.07	1.89
18	4.33	4.74	87.33	1.98
19	4.50	2.87	55.91	1.59
20	4.50	3.26	64.9	1.74

Twenty pairs of variates are considered, and for any correlation between these to be statistically significant ($P < 0.05$), the value of the correlation coefficient must be greater than 0.4438 (*3*).

When the integral dose alone is compared with the length of the latent period, the value of the correlation

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coefficient is −0.244, and no significance can be attached to this figure. But when the ratio of the integral dose to the body weight is compared with the length of the latent period the value of the correlation coefficient is −0.567, and the correlation is statistically significant. The P value for this correlation is in fact less than 0.01 but greater than 0.001.

When the ratio of the integral dose to the total body surface area is compared with the length of the latent period, the value of the correlation coefficient is −0.529, a value not significantly different from the coefficient obtained when body weight was used.

These findings indicate that if the length of the latent period can be regarded as an indication of one aspect of the biological response to x-radiation, then its length is not only a function of the dose of radiation but also of the size of the individual irradiated. In the opinion of the authors, the dependence of dose upon body size may well indicate that a diffusible metabolite plays an essential role in the development of those symptoms that occur within a few hours of exposure to x-rays.

References

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A Method for the Quantitative Study of Surface Wounds

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One of the difficulties in the study of wound healing and of factors influencing this process is the lack of quantitative criteria. In the case of cut wounds, measurement of the tensile strength of the scar has been used (*1*). Histological study of granulation tissue has provided some yardstick of the healing process in other types of wounds.

In the case of surface wounds such as burns or pressure sores where one wishes to study the rate of granulation and epithelialization the surface area of the wound constitutes a good objective index of wound healing (*2*).

The following method has been found to give reproducible results in the study of decubital ulcers in man. A Coreco camera is used to take 35-mm Kodachrome photographs of wounds at frequent intervals. This camera provides constant illumination, focal distance, and aperture. The frames of it are modified by superimposing upon them a centimeter scale made of cellophane and placed in such a way that it will show on the photograph in close apposition with the pictured wound. These Kodachromes are projected in a standard enlarger adjusting the magnification so that 1 cm on the screen corresponds exactly to 1 cm on the centimeter scale on the photograph. A thin white cardboard is used as a screen. The outline of the projected wound is drawn upon the cardboard. The tracing is cut out and weighed by means of an analytical balance. Ten squares, measuring 1 cm square, are drawn upon the same piece of cardboard and cut out. These are weighed, the weights are averaged and the figure obtained is used to divide the weights of the various

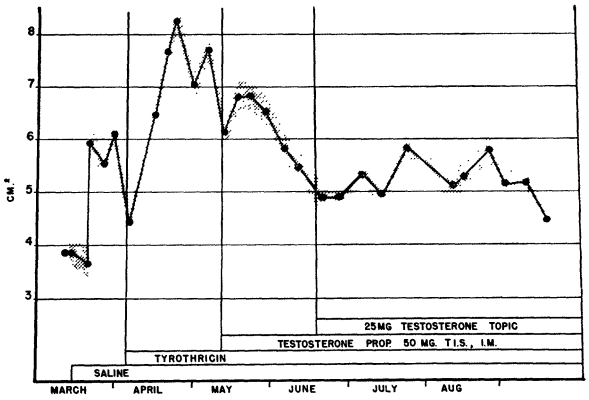

FIG. 1. Long-term study of a patient with hemiplegia showing the quantitative change of the surface of a sacral bed sore under various regimens of treatment. This patient's general condition remained the same throughout. This chart demonstrates the enlargement of bed sores that occurs whenever the treatment is changed; also a distinct deleterious effect of Tyrothricin. The magnitude of the technical error is indicated by the shaded area.

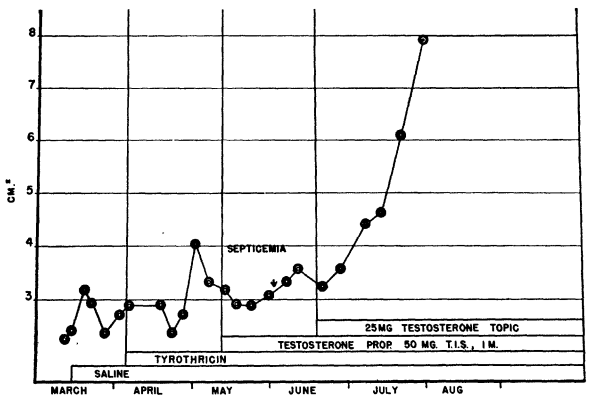

FIG. 2. Shows the same observations as in Fig. 1 although less pronounced, and also the relationship between the size of the bed sore and the general physical state of the patient. This patient developed a septicemia and died, with concurrent enlargement of the bed sore.

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