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Experimental Hypertension Produced by a Plastic Capsule Applied to the Kidney

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Various methods (*1*, *2*, *3*) have been described for producing experimental hypertension, including application of cellophane or silk around the kidney, and constriction of the renal artery. These methods, however, have limitations when applied to small mammals. The writer has found that an effective plastic capsule can be produced around the kidney by spraying that organ, when properly exposed, with a solution of plastic. This procedure is outlined briefly here.

Dogs were anesthetized with sodium pentobarbital 32.5 mg/kg intraperitoneally. Using the retroperitoneal approach, the kidney was exposed and gently lifted out of the body cavity. The fat and fascia surrounding the kidney were carefully removed, whereas the true renal capsule was removed in some cases and not in others. Aseptic technique was employed at all times and the operated animal was given regular doses of penicillin until the wound had completely healed. The operation was performed unilaterally. Two weeks later the procedure was repeated on the opposite side.

Plastic (butyl methacrylate polymer, procured from the E. I. du Pont Company) dissolved in acetone (200–250 ml per 100 g plastic) was sprayed over the kidney. This plastic solution hardens quickly into a tough capsule which is not disturbed by body fluids, body temperature, or movements of the animal.

A large atomizer was used to spray the plastic. The spraying apparatus must be washed with acetone to keep the openings patent.

Blood pressure in animals having plastic capsules applied to both kidneys by this method persisted at levels of 190 mm Hg and above. The rate of rise in blood pressure essentially followed that previously described by Page (*2*, *3*) when cellophane was used.

As control against the possible effects of the acetone in which the plastic was dissolved, tests were made using comparable quantities of acetone alone. No effects on the animals were noted.

The plastic may also be dissolved in toluene. The hardening process naturally takes a little longer, but the spraying apparatus is not as difficult to keep clean and patent.

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Absorption Effects in Volume Irradiation of Microorganisms

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Three types of experiments are generally performed to obtain the survival curves of organisms subjected to radiation: surface irradiation, volume irradiation, and volume irradiation with stirring. From the shapes of these curves it is possible to consider this process in terms of the target theory (*1*). It is difficult to attach physical significance to target area in the case of ultraviolet irradiation. Nevertheless, the relative target areas obtained from an action spectrum indicate the probability of an inactivation as a function of wavelength. In volume irradiations, unless the absorption of the medium and organisms are taken into consideration, erroneous values may be obtained for the relative target areas.

The standard single-hit target theory expression for the survival curve of irradiated microorganisms (*2*) is:

$$\frac{N}{N_0} = e^{-SB} \qquad (1)$$

where N_0 is the original number of organisms, N the number of survivors, S the target area, and B the dosage per unit area. This relation applies rigorously for the cases of surface irradiation and volume irradiations in which the total absorption of radiation by the suspending medium and suspended particles is negligible.

In general, actual irradiations are volume processes with finite absorption. We may distinguish two cases: case I, in which the organisms are fixed in the suspending media; and case II, in which the organisms are constantly stirred.

Case I. Monochromatic radiation is absorbed according to Beer's Law.

$$\frac{B}{B_0} = e^{-\alpha x} \qquad (2)$$

where B_0 is the incident intensity, B the intensity at any point x, and α is the absorption coefficient. Consider an

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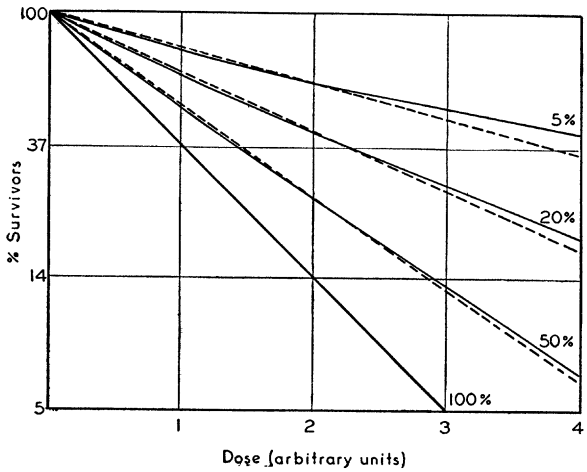

FIG. 1. Solid lines are predicted curves; broken lines are the straight line approximations. Labels on curves indicate percent transmission of irradiated sample.

absorption cell of area A and length L. This may be divided into a number of smaller volumes $A\,dx$. Equation (1) may be written for each of these small volume elements as follows:

$$\frac{Q(x)}{Q_0} = e^{-SB_0 e^{-\alpha x}} \tag{3}$$

where Q_0 is the original number of organisms per unit volume and $Q(x)$ the number of survivors per unit volume at x. This may be rewritten as follows:

$$\frac{LAQ(x)\,dx}{LAQ_0} = e^{-SB_0 e^{-\alpha x}}\,dx \tag{4}$$

and integrated as x goes from 0 to L

$$\int_0^L AQ(x)\,dx = N \text{ (total number of survivors)} \tag{5}$$

$$LAQ_0 = N_0 \text{ (original number of organisms)} \tag{6}$$

We then have

$$\frac{LN}{N_0} = \int_0^L e^{-SB_0 e^{-\alpha x}}\,dx \tag{7}$$

which may be put in terms of the standard integral[2]

$$\frac{N}{N_0} = \frac{1}{\alpha L}\int_{SB_0 e^{-\alpha L}}^{SB_0} \frac{e^{-u}}{u}\,du \tag{8}$$

Plotting log N against B_0 for various values of αL we get a family of very nearly straight lines until we get to very low survival as shown in Fig. 1. Provided we know αL, which can be obtained from the percent transmission, we may reduce all data to equivalent surface radiation by multiplying B_0 by an appropriate correction factor (see Table 1). This gives us the dose necessary to give the same inactivation if the organisms were spread on a surface. The correction factor depends on the percent of radiation transmitted through the actual irradiated sample, and is therefore a function of the wavelength, the material irradiated, and the depth of this material.

Case II. In a stirred suspension, equation (8) holds only for a very short time, dt, after which stirring gives a uniform distribution in which N_0' is now equal to N after time dt. If we suppose the total irradiation time is τ, the total surface dose is then given by $B_0'\tau$ where B_0' is the rate of irradiation. If dt is given by $\frac{\tau}{g}$ where g is a very large number, we get the following expression for the number of survivors

$$N = N_0\left[\frac{1}{\alpha L}\int_{\frac{SB_0'\tau e^{-\alpha L}}{g}}^{\frac{SB_0'\tau}{g}} \frac{e^{-u}}{u}\,du\right]^g \tag{9}$$

For complete stirring $dt \to 0$ or $g \to \infty$. Taking the limit of expression (9) as $g \to \infty$ we get

$$N = N_0 e^{-SB_0}\left(\frac{1-e^{-\alpha L}}{\alpha L}\right) \tag{10}$$

This time the plot of log N against B_0 gives a family of exact straight lines in which B_0 can be multiplied by a correction factor to give the equivalent surface dose. Equation (10) may be derived more simply by assuming that the organism is just as likely to be found in a given part of the cell as in any other part. The radiation it receives is thus the space average of the radiation throughout the cell.

$$B_{avg} = \frac{1}{L}\int_0^L B_0 e^{-\alpha x}\,dx = B_0\left(\frac{1-e^{-\alpha L}}{\alpha L}\right) \tag{11}$$

$$\frac{N}{N_0} = e^{-SB_{avg}} = e^{-SB_0\left(\frac{1-e^{-\alpha L}}{\alpha L}\right)} \tag{12}$$

Thus the results of both types of volume irradiation may be expressed as equivalent surface radiations when B_0 is corrected in the appropriate manner.

TABLE 1

Transmission	Correction factor (stirring)	Correction factor* (no stirring)	Maximum error due to straight line approximation for case I
%			%
100	1	1	0
90	.95	.94	5
80	.90	.89	5
70	.84	.83	5
60	.78	.77	5
50	.72	.71	5
40	.66	.65	5
30	.58	.56	10
20	.50	.46	10
10	.39	.35	10
5	.32	.27	15

* The correction factors for the nonstirring case are applicable, within the limits of error given, for survival from 100% to 37%. For lower survival rates (especially for high absorption) data must be compared directly to equation (8).

[2] This integral is evaluated in *Tables of sine, cosine, and exponential integrals.* Federal Works Agency, 1940. Vol. II.

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