Action Spectrum for the Photodestruction of Bilirubin[1] (35302)

STANLEY C. GLAUSER, SONCERIA A. LOMBARD, ELINOR M. GLAUSER, AND THOMAS R. C. SISSON

Deparments of Pharmacology and Pediatrics, Temple University School of Medicine, Philadelphia, Pennsylvania, 19140

It was noted by Fischer and Herrle (1) in 1938 that bilirubin was susceptible to photodestruction. He found that this reaction was dependent on the solvent and on the presence or absence of salts in the solvent. After 1957, this reaction was used as a clinical technique in the therapy of hyperbilirubinemia in the neonatal human (2, 3). It was felt that this therapy was probably less dangerous than the use of exchange transfusions to lower the serum bilirubin levels as it did not carry with it the dangers of hyper- and hypovolemia, electrolyte imbalances, and coagulation difficulties (4). Recent studies (5) have shown that this phototherapy is not entirely innocuous as it can destroy the retina of diurnal animals if the eyes are not adequately protected. Because the efficiency of the therapy could be increased without an actual increase in total energy output of the lights if only the exact wavelength for the photodestruction of bilirubin were used, it was decided to investigate the action spectrum for the photodestruction of bilirubin.

Material and Methods. The experimental procedure consisted in dissolving between 3 and 7 mg/100 ml of bilirubin in plasma. Each such solution was divided into 15 aliquots of 3 ml each. The first aliquot was kept unexposed to light for the entire period of the experiment and the initial and final bilirubins of this sample were referred to as the 100% value for this bilirubin concentration. Each of the other aliquots was placed in a 10 by 10-mm cuvette and placed in the cell chamber of an Aminco-Bowman spectrofluorimeter for 1.5 hr. While in the cell chamber the sample was exposed to the light from a xenon arc lamp which had been mono-

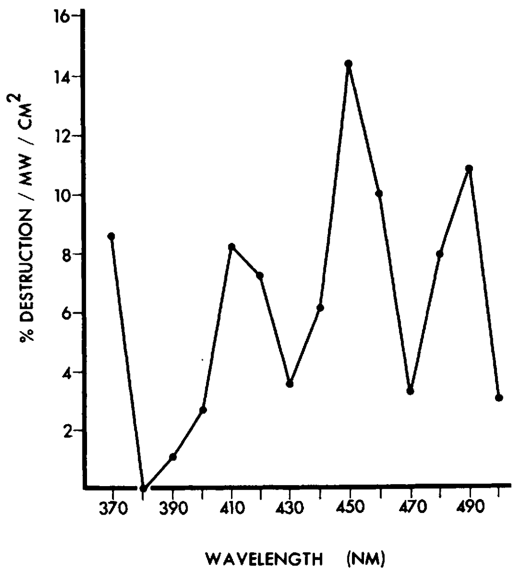

FIG. 1. Variation in the mean percentage bilirubin destroyed per milliwatt incident radiation per centimeter squared as a function of wavelength from 370 to 500 nm. Four peak values for the destruction of bilirubin occur at 370, 410, 450 and 490 nm. Radiation below 390 nm is absorbed by the Plexiglas shields used in clinical phototherapy. The most effective wavelength for the destruction of bilirubin is 450 nm.

chromated by the spectrofluorimeter. The wavelengths for exposure started with the 370 nm and increased in increments of 10 nm to 500 nm. After all aliquots had been exposed, the bilirubin levels were read in an American Optical Bilirubinometer.

Results and Discussion. Measurements with a radiometer showed that the energy of the monochromated xenon beam was 1.175 $\pm$ 0.15 mW/cm^2. Thus, over the entire spectral range the results were not a consequence of variation in beam energy. The maximum

[1] Aided by Grant Nos. AM-10072 and HE 08752, NIH, U.S. Public Health Service.

energy emission occurred at 480 nm where there was relatively little photodestruction of bilirubin; while the four wavelengths that showed increased photodestruction of bilirubin, had average or below average energy emissions.

The results of the experiments over the concentration range of 3 to 7 mg/100 ml of bilirubin in plasma were all essentially the same and thus, could be pooled by referring to percentage destruction of bilirubin with the unirradiated control taken as 100%. The results are shown in Fig. 1. The largest amount of destruction occurred at a wavelength of 450 nm with a half-bandwidth of slightly less than 20 nm. The second most efficient wavelength for photodestruction of bilirubin occurred at 490 nm also with a half-bandwidth of slightly less than 20 nm. There were two relatively less efficient wavelengths at 410 and 370 nm. The 370-nm wavelength is probably of little importance clinically as the Plexiglas shields in front of the lamps screen out all but 2 to 3% of the beam intensity at wavelengths below 390 nm (6) and this peak is not very efficient at best. The most important wavelength for the efficient photodestruction of bilirubin appears to be at 450 nm with a significant amount of activity remaining at 460 nm.

Thus it would appear most desirable, from the results of this study, to have a lamp in which the phosphor emitted most of the energy close to 450 nm. Such a lamp has been developed[2] and has been employed in clinical studies (3). This maximizes the amount of bilirubin destroyed per joule of radiant energy received by the infant undergoing phototherapy. This one wavelength gives specific therapy for the destruction of bilirubin, rather than a shotgun approach in which a wide spectrum of energy is delivered to the infant, only a small portion of which is effectively used in therapy.

[2] Westinghouse Corp; lamp designation F 20T12/BB.

1. Fischer, H., and Herrle, K., Hoppe-Seyler's Z. Physiol. Chem. **251**, 85 (1938).

2. Cremer, R. I., Perryman, P. W., and Richards, D. H., Lancet **1**, 1094 (1958).

3. Sisson, T. R. C., Kendall, N., Davies, R., and Berger, D., Trans. Amer. Pediat. Soc. **1969**, 19.

4. Baker, R. J., and Nyhus, L. M., Surg. Gynecol. Obstet. **130**, 665 (1970).

5. Sisson, T. R. C., Glauser, S. C., Glauser, E., Tasman, W., and Kuwabara, T., J. Pediat. **77**, 221 (1970).

6. Berger, D., personal communication.

Received Sept. 2, 1970. P.S.E.B.M., 1971, Vol. 136.