Radioactive Rose Bengal Test as a Quantitative Measure of Liver Function. (22761)

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The radioactive rose bengal test, first described by Taplin, Meredith and Kade(1), promises to be one of the most sensitive known tests of liver function. By placing a radiation detector over the liver and injecting a small amount of I^{131}-tagged rose bengal intravenously, one can measure the rate of uptake and excretion of the dye. Normally, the activity rises to a peak in about 30 minutes and then falls as the dye is excreted via the biliary system into the bowel (Fig. 1). Where liver function is impaired, the rate of rise or fall, or both, is slower than normal. The original method for interpreting these uptake and excretion curves was semiquantitative, based on a visual comparison of each curve with a cluster of "normal" curves. Variations in size of patient, liver, or dose of tracer make this method quite unreliable. A purely quantitative analysis is described in the rest of this article.

Method. It is apparent that, at any time, liver radioactivity (L) is equal to the difference between the amount of activity taken up $(1-U)$ and the amount excreted $(1-E)$, symbolically, $L = (1-U)-(1-E)$. Therefore, $L = E-U$. Both U and E decrease logarithmically with time; therefore, each of these components is characterized by a constant, which we may call "uptake halftime" and "excretion halftime," by analogy with the "halflives" of radioactive elements. The uptake halftime is the period in which the liver takes up half the circulating dye from the blood; the excretion halftime is the period in which half the amount taken up is excreted through the bile ducts.

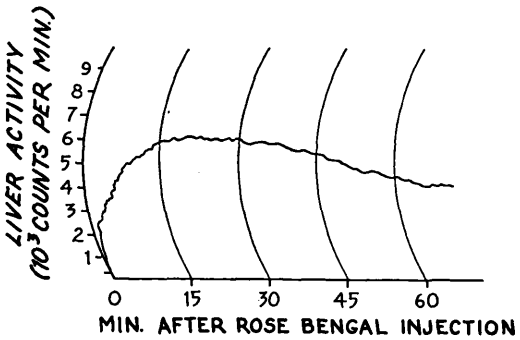

FIG. 1. A normal I^{131} rose bengal uptake excretion curve.

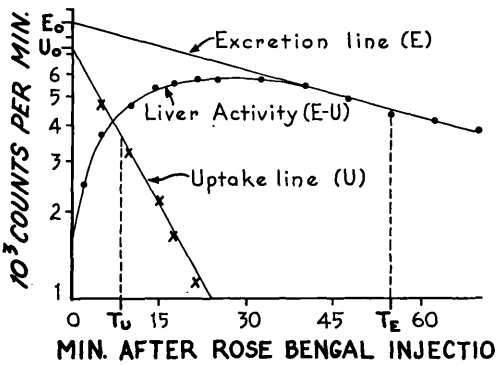

FIG. 2. Graphical analysis of the curve in Fig. 1. The uptake halftime (T_U) is 8 min., the excretion halftime (T_E) 55 min., and the liver blood volume $\left(\frac{E_0-U_0}{E_0}\right)$ is 18% of the total blood volume.

If we consider as "time zero" the time after radioactive rose bengal has been injected into the bloodstream but before any has been taken up by liver cells, then, at this time: Liver radioactivity = radioactivity of blood in liver $= E_0 - U_0$ and since E_0 represents the total radioactivity injected,

$$R \equiv \frac{\text{Liver Blood Volume}}{\text{Total Blood Volume}} = \frac{E_0-U_0}{E_0}.$$

The shape of each curve is determined by the 3 quantities, uptake halftime (T_U), excretion halftime (T_E), and fractional liver blood volume (R), and these constants can be found by graphical analysis.

Uptake excretion curves were obtained by the method of Taplin, Meredith and Kade(1) using a lead-shielded scintillation detector placed over the liver and aimed away from the gall bladder, with a counting rate meter

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TABLE I. Summary of Mean Values of Quantitative Radioactive Rose Bengal Test.*

Clinical diagnosis	No. of patients	Uptake halftime, min.	Excretion halftime, min.	Liver blood vol, % of total blood vol
Normal	35	9	92	18
Acute hepatitis	3	11	185	32
Recovered hepatitis	7	9	129	20
Laennec's cirrhosis	18	18	300	32
Biliary cirrhosis	3	28	2800	35
Heart failure	2	21	106	24
Acute ulcerative colitis, with liver damage	1	7	260	23
Same case, after improvement of colitis		6	145	18
Common bile duct obstruction (carcinoma of head of pancreas)	1	15	2200	23
Same case, 1 wk after surgery (Whipple procedure)		9	140	21

* These values were derived from 42 uptake excretion curves published by Taplin, Meredith and Kade, and 28 curves recorded at Stanford Hospital and the Palo Alto Clinic. Comparison of the two groups reveals very nearly the same avg values for patients with the same diagnosis. The stand. dev. of each value is close to ± 25%.

and recorder. Each patient was given intravenously about 25 μg of rose bengal in 1 cc of saline, having activity of about 25 μc. Each record was continued until the peak activity was passed and the counting rate was well on the down slope (Fig. 1). Each curve is analyzed as follows. After background activity is subtracted, the curve is transposed to semilogarithmic paper (Fig. 2). A straight line (E) is drawn from the ordinate through the descending limb; this is the excretion line. The uptake line (U) is obtained by plotting differences between E and the rising portion of the curve, and drawing another straight line from the ordinate through these points. The uptake halftime is the time when $U = \frac{1}{2} U_o$, the excretion halftime is the time when $E = \frac{1}{2} E_o$. Fractional liver blood volume, $R = \frac{E_o - U_o}{E_o} \times 100\%$.

Results. Average values derived from data in this clinic and from the published curves of Taplin, Meredith and Kade(1) are presented in Table I. The standard deviation is about ± 25% in each group. The cases of ulcerative colitis and carcinoma of the head of the pancreas show how the test results in single individuals change with altered clinical state.

Discussion. From this series, it appears that hepatocellular damage is manifested by delayed uptake and excretion, obstructive processes cause delayed excretion, and circulatory failure, as expected, reduces the uptake rate. This test appears to have great practical value in the differential diagnosis of jaundice and liver disease.

Summary. The radioactive rose bengal test, a very sensitive test of liver function, can be analyzed graphically to yield three quantities —uptake halftime, excretion halftime and fractional liver blood volume. The values in various liver diseases seem to be characteristic of the disease and to indicate whether cellular damage or obstruction predominates.

1. Taplin, G. V., Meredith, D. M., Jr., and Kade, H., *J. Lab. and Clin. Med.*, 1955, v45, 665.

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