PREDICTION OF THE EFFECT OF PHOTOTHERAPY IN NEWBORNS

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Phototherapy (PT) is based on the interaction between light and bilirubin molecules in the skin. This photoreaction can be described by the following equation [1,2]:

\[ c = c_0 e^{-k t^*} \]  \hspace{1cm} (1)

where
- \( c = \) serum bilirubin concentration prior to PT
- \( t^* = \) duration of PT
- \( c_0 = \) serum bilirubin concentration after illumination
- \( k = \) photoconstant

The photoconstant can be taken as a measure of the efficacy of PT. The higher the photoconstant, the higher the efficacy. As a result of the interaction between light and bilirubin in the skin, the following dependencies of the photoconstant may be considered (fig.1).

In this diagram light is symbolized by lines, (broken lines indicating ineffective irradiance) and bilirubin molecules by points. The following conclusions are evident [3]:

1) The change of the serum bilirubin concentration (SBC) under PT is proportional to the bilirubin concentration. A doubling of the number of bilirubin molecules results in a doubling of the number of interactions.
2) The change of the SBC under PT is proportional to the effective irradiance, \( E \).
3) The change of the SBC under PT is proportional to the illuminated surface area, S.

4) The change of the SBC under PT is inversely proportional to the volume containing the bilirubin, and therefore inversely proportional to the body weight, G.

Summarizing these statements the equation for the photoconstant is obtained:

$$k = k^*c_0 \frac{S}{G} E$$

(2)

in which $k^*$ is a general photoconstant. The so called 'photoreaction' equation has the following form:

$$c = c_0 e^{-k^*c_0 \frac{S}{G} E} t^*$$

(3)

This photoreaction equation describes the change of SBC for Gunn rats under PT (Fig.2). The applicability of this equation for Gunn rats is based on minor fluctuations in the SBC prior to the PT, this means 1 month old homozygous Gunn rats are in a steady state relative to their SBC. This is not the case for human babies (Fig.3). Here the concentration increases during the first days of life - phase one - and after reaching a maximum, decreases during the second phase. When PT is begun during the first phase of normal increase, changes in the SBC induced by the illumination may not be very impressive. In this phase it is the rate of increase in the SBC that is diminished as a result of PT, after which the SBC will persist for some time on a plateau, which is then followed by at first, only a slight decrease. When PT is started during the second phase, the normally expected decrease will be accelerated by the light. Therefore, it is incorrect - but unfortunately common in the literature - to compare the efficacy of PT in babies with the same SBC at the onset of therapy, but in different phases. For a mathematical