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Effect of phototherapy on neonatal fluid and electrolyte status

by

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Three groups of 'healthy' fullterm infants with hyperbilirubinaemia exposed to continuous phototherapy of different intensities, increased their oral intake of milk formula by 33%, 48% and 52% at 24, 48 and 72 h, respectively, irrespective of the intensity of exposure; this was significantly more than in the controls, who were swaddled. Serum osmolality and electrolyte values demonstrated no significant change from pre-phototherapy values, and were similar to those of the control group except for significantly raised potassium levels at 72 h in 2 of the 3 phototherapy groups. These raised values were, however, not dangerously high, and rapidly reverted to normal with cessation of phototherapy. The osmolality of the milk formula feeds was 272.4 ± 8.2 (mean ± SE) mmol/kg, potassium 27.8 ± 1.4 mmol/l and sodium 16.0 ± 0.8 mmol/l.

Phototherapy even for 72 h does not significantly affect the fluid and electrolyte status of hyperbilirubinaemic infants fed with fairly high solute load milk formulas.

Infants exposed to phototherapy display increased muscle blood flow [3, 8] and increased insesnsible water loss [2, 3, 7]. The effect of phototherapy on the fluid and electrolyte status of such infants has not been studied. The present paper documents an attempt at such a study.

Methods and Material

Three types of photherapy set-ups were utilised: an overhead seven-lamp set-up using Philips daylight fluorescent lamps TL20W/54 (radiance 250 μW/cm² in the 425—475 nm range and 285 μW/cm² in the 400—480 nm range, radiant heat 0.0324 cal/cm²/min), a similar seven-lamp set-up using Philips blue lamps TLAK40W/03 (radiance 375 and 490 μW/cm² respectively, and radiant heat 0.0405 cal/cm²/min), and a 15-lamp multi-directional set-up using the same Philips blue lamps (radiance 850 and 1.115 μW/cm² respectively, radiant heat 0.1080 cal/cm²/min). The temperature of the immediate environment adjacent to the infant's skin was 31.5°C for the daylight set-up, 32.5°C for the seven blue lamp set-up, and 33.7°C for the multi-directional set-up, and the room temperature, 28—30°C. The humidity ranged from 70 to 75%. The set-ups have been described before [4, 5]. The radiance measurements were made by the 11A Photometer/Radiometer (United Detector Technology Inc., USA) and the radiant heat measurements by the Moll-Grozynski solarimeter (Kipp & Zonen, Holland).

'Healthy' fullterm infants with hyperbilirubinaemia (bilirubin ≥ 255 μmol/l) were exposed to phototherapy commencing in the morning, in whatever set-up available at the moment. A fourth group of full-term infants with no hyperbilirubinaemia, and not exposed to phototherapy, served as controls. They were swaddled.

Each infant was exposed unclothed, except for eyepads, to 72 h continuous phototherapy interrupted only for nursing, 3-hourly feeds, and 6-hourly bilirubin monitoring. Venous blood was obtained just prior to phototherapy, at 24 h, and at the end of phototherapy at 72 h. A fourth sample was obtained a day later. Venous blood was obtained in the same manner in the controls. Urine samples were collected at about the same time as the blood samples; for ease of collection free from contamination, urine was only collected from male infants. The infants were fed ad libitum during the period of study with the same standard milk formula; the amount fed was carefully charted at the end of every feed. The number of stools passed was also charted.

The following tests were performed on the sera: osmolality, urea, potassium, sodium and chloride. Urine osmolality and urea were also determined. Osmolality was determined by the Advanced Digimatic Osmometer (Advanced Instruments Inc., USA), urea by the Beckman BUN Analyser, potassium and sodium by flame photometry (IL 343, Instrumentation Laboratory, Lexington, MA, USA), and chloride by the Radiometer CMT 10 chloride titrator. Sera with obvious haemolysis were discarded. Total bilirubin was determined by the AO Bilirubinometer (American Optical, USA) and direct bilirubin in random samples by the method of Malloy and Evelyn [1].

The standard milk formula was sampled at random on 12 consecutive days, for determination of osmolality, potassium and sodium values. For determination of potassium and sodium, the milk samples were dried for 24 h at 100°C, then incinerated at 350°C for 8 h. The residue was dissolved in 0.1 N hydrochloric acid. This solution was diluted 1:200 with lithium nitrate, 15 mmol/1. Potassium and sodium were measured by flame photometry.

Seventy-seven infants with hyperbilirubinaemia divided into three groups for the three different forms of phototherapy were studied. A further 23 infants served as controls (Table I). The number of infants less than 48 h of age was 2 in the daylight lamp group, 0 in the 7-blue lamp group, 6 in the 15-blue lamp group and 2 in the control group; the difference was only significant between the 7-blue and 15-blue lamp groups ($p < 0.02$).

Results

All the infants remained well during the period of study. Normothermia was maintained in all infants; the group under intense phototherapy (15-lamp set-up), however, required increased air circulation through the open set-up from an overhead ceiling fan to maintain normothermia. The response to phototherapy was satisfactory in all infants, and most marked in the 15-lamp group. The responses could not be compared since the age of the infants was not comparable among the three groups. Direct acting bilirubin did not exceed 17 μmol/1 in the random samples determined.

Oral intake of formula was comparable in all four groups on infants at commencement of the study. Increased oral intake occurred in all the three groups of infants exposed to phototherapy with no significant difference among them (Fig. 1). Twenty-four h after exposure, the oral intake

TABLE I

Data of the Infants

	Group			
	Control	7 white lamps	7 blue lamps	15 blue lamps
Number M:F	16:7	16:9	17:8	20:7
Birth wt (g)				
Mean	3295	3112	2928	3240
S. E.	72	65	81	115
Gestation (wk)				
Mean	39.6	39.4	39.4	39.1
S. E.	0.2	0.2	0.2	0.2
Age (days)				
Mean	3.7	3.7	3.3	3.1
S. E.	0.3	0.2	0.2	0.2
24-h oral intake (ml/kg body wt)				
Mean	133.5	136.6	133.0	133.5
S. E.	5.0	6.5	8.4	9.2
Serum osmolality (mmol/kg)				
Mean	278.2	282.1	276.2	285.0
S. E.	3.4	3.5	3.1	2.7
Serum urea (mmol/1)				
Mean	5.39	5.28	5.39	4.93
S. E.	0.38	0.30	0.36	0.23
Serum potassium (mmol/1)				
Mean	4.80	4.97	4.86	4.92
S. E.	0.10	0.14	0.15	0.10
Serum sodium (mmol/1)				
Mean	138.7	139.8	139.1	140.2
S.E.	1.1	1.1	1.0	0.8
Serum chloride (mmol/1)				
Mean	102.8	105.3	105.0	104.2
S. E.	0.8	0.8	1.6	0.8
Bilirubin (mmol/1)				
Mean	—	278 7	278.7	289.0
S. E.	—	3.4	3.4	3.4

Protein content of milk: 2.8 g/dl

had increased by 33%, after 48 h by 48% and after 72 h i.e. at the end of phototherapy, by 58%. This increased intake was significantly more than that of the control group ($p > 0.001$) of infants (6% increase at 24 h, 9% at 48 h, and 13% at 72 h). After phototherapy, the oral intake fell, though it still remained more than that of the control group. The number of stools increased slightly from an average of 4.5 to 6 stools per day, during phototherapy.

The serum osmolality in all three groups of infants increased initially, but this was not significantly more than that of the control group at 24 h; it approximated that of the

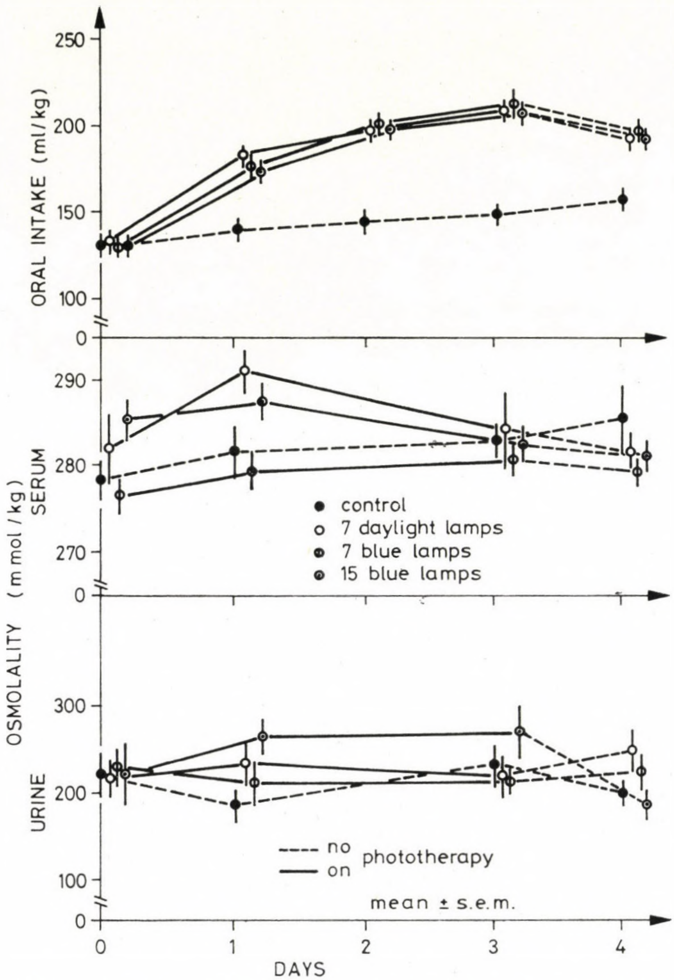

FIG. 1. Effect of phototherapy on oral intake and osmolality

control group at 72 h (Fig. 1). Urine osmolality did not demonstrate any appreciable change compared to that of the control group. The increase in the group exposed to intense phototherapy was not significant. Serum urea increased in all groups (Fig. 2), the values being comparable in the control and phototherapy groups. Urinary urea demonstrated wide fluctuations among infants within the same group, with no significant difference in the values of the four groups.

Serum potassium (Fig. 3) demonstrated a rise at 24 h in the 7-blue lamp group and daylight lamp group of infants, but this was not significant ($0.2 > p > 0.1$); a slight fall was observed in the 15-lamp group. A significant rise was observed in two groups at 72 h of phototherapy ($p > 0.001$ for the 15-lamp group,

TABLE II

Osmolality, potassium and sodium values in the milk feeds (n = 37)

	Mean	S. E.
Osmolality (mmol/kg)	272.4	8.2
Potassium (mmol/1)	27 91	1.45
Sodium (mmol/l)	16.05	0.81

$p < 0.05$ for the 7-blue lamp group) but not in the daylight lamp group ($0.3 > p > 0.2$).

The osmolality of the milk formula was consistently less than 310 mmol/kg, sodium 20 mmol/1 and potassium 31 mmol/1 as determined in the 37 random samples obtained over a 12-day period (Table II). The protein content was 2.8 g/dl.

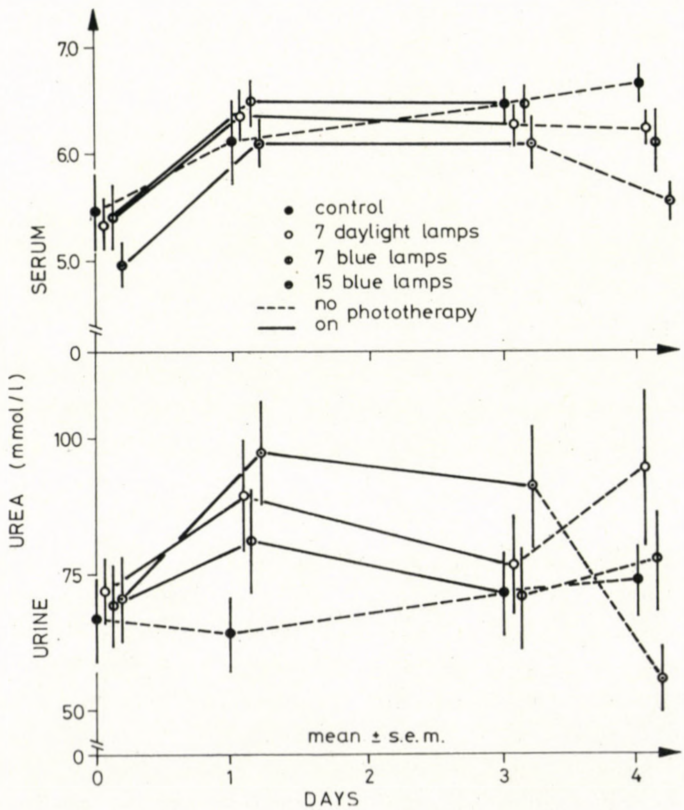

FIG. 2. Serum and urine urea values with phototherapy

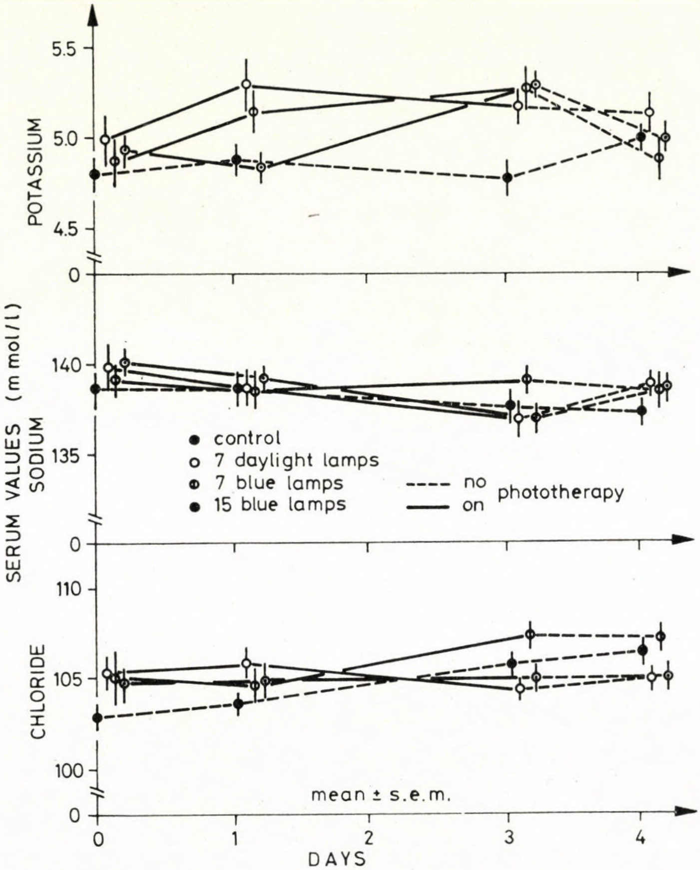

FIG. 3. Effect of phototherapy on serum electrolyte values

Discussion

Oral intake of the infants under phototherapy increased in almost the same manner in all three groups of infants, in spite of the different quality and quantity of light and degree of heat. This increased intake was apparently sufficient to compensate for the increased fluid loos. The accompanying solute load in the increased fluid intake apparently posed no serious problem as demonstrated by the serum osmolality and sodium values which remained within the normal range. The urine osmolality values also demonstrated no significant rise further confirming the conclusion. Had the relatively low urine osmolality been due to a failure of renal ability to concentrate, the serum osmolality would have reflected this derangement.

The serum urea values increased in the infants during phototherapy but this was matched by a similar rise in the controls whose oral intake was less. Apparently, the infants exposed to phototherapy could cope with the extra protein load in the increased feeds.

The increased potassium values in the two groups with more intense phototherapy and heat after 72 h exposure is difficult to explain. The possibility of a slight temporary potassium imbalance during intense continuous phototherapy has to be considered. The fairly high potassium intake could also be contributory. The values were, however, not dangerously high, and rapidly reverted to pre-phototherapy levels with cessation of treatment.

The effect of environmental humidity on fluid balance during phototherapy has yet to be evaluated. In the present study, no obvious sweating was observed during phototherapy, demonstrating that evaporation with adequate temperature control was still fairly efficient at a humidity of 70—75% and an ambient temperature of 31—34°C. Increased air circulation was required in the group with intense phototherapy indicating the need for increased evaporation for adequate temperature control. The oral intake in this group of infants did not, however, differ significantly from those of the other two groups; the electrolyte levels and the osmolality remained comparable. Whatever extra fluid loss had occurred in this group, it was apparently not significantly greater than those of the other two groups.

Phototherapy under conditions of fairly high humidity seems to be safe where fluid and electrolyte status are concerned, even with feeds of a formula containing a relatively high solute load as used in the present study. Where infants are healthy, feeds can be administered ad libitum, but in ill and feeble infants, increased fluid intake is mandatory. With low birth weight infants, a lower solute formula would seem advisable.

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