Discussion

The radiant flux of a light source in $\mu W/cm^2$, measures the total power of light radiation within a defined wavelength band. A dose-response curve has been contructed by Mims *et al.*[5] demonstrating that increments of radiant flux increase photodegradation of bilirubin in a near linear manner. This curve assumes that the irradiance of incident light is uniform over the entire infant, and the results of this study indicate that the intensity of light on different areas of the incubator varies considerably.

The usual position for an infant to be nursed in an enclosed incubator is towards the front to give easy access through the ports or door. From this study it appears that an infant nursed on the front third of the mattress receives less than 40% of the maximal light impinging on the centre of the mattress.

Further studies on the optimal number and orientation of the fluorescent tubes should ensure that a more even distribution of light occurs. A simple solution may be a plastic diffusing element under the tubes to distribute the light more evenly over the entire incubator surface.

References

1 Dobbs R H, Cremer R J. Phototherapy. *Arch Dis Child* 1975; **50**: 833–6.

2 Cremer R J, Perryman P W, Richards D H. Influence of light on the hyperbilirubinaemia of infants. *Lancet* 1958; **i**: 1094–7.

3 Bonta B W, Warshaw J B. Importance of radiant flux in the treatment of hyperbilirubinemia: failure of overhead phototherapy units in intensive care units. *Pediatrics* 1976; **57**: 502–5.

4 Sisson T R C, Kendall N, Davies R E, Berger D. Factors influencing the effectiveness of phototherapy in neonatal hyperbilirubinemia. *Birth Defects* 1970; **6**: No. 2, 100–5.

5 Mims L C, Estrada M, Gooden D S, Caldwell R R, Kotas R V. Phototherapy for neonatal hyperbilirubinemia —a dose response relationship. *J Pediatr* 1973; **83**: 658–62.

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Comparison of efficiency of commercially available phototherapy units

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SUMMARY The efficiency of two phototherapy units was compared by exposing solutions of bilirubin *in vitro*. Both units are commercially available.

Phototherapy is a procedure that is no longer considered to be free of complications. The efficiency of photodegradation by two phototherapy units was compared in an effort to discover which unit exposed the infant to the least light energy for greatest bilirubin decay.

Methods A standard solution containing about 360 μmol/l (21 mg/100 ml) bilirubin (Versatol Paediatric*) was prepared. 14 glass microcapillary tubes were filled with this and placed under the phototherapy unit. An estimate of total bilirubin was made at zero time on two tubes using a bilirubinometer (American Optical Instruments). The other 12 tubes were placed in the light source to be tested at the centre of the mattress of an Air-Shields Isolette incubator with the motor switched off.

The incubator had been placed in a lightproof room which was not affected by changes in external temperature. The two phototherapy units were the Air-Shields S400 (four tubes) and the Vickers Medical (four tubes); both were supplied by the manufacturers with standard new white and blue fluorescent tubes. The units were fitted consecutively with four white, four blue, and a combination of two blue and two white tubes. Each was assessed on its ability to degrade the bilirubin solution in the capillary tubes.

The light sources were placed 45 cm directly over the incubator and left on for 24 hours. Two capillary tubes were removed at intervals of 1, 2, 3, 6, 9, and 24 hours and the total bilirubin in each tube was estimated. The light intensity at the centre of the incubator mattress was recorded by means of a newly calibrated spectroradiometer (Air-Shields S450) for each of the three combinations of light in both phototherapy units. These results are expressed in $\mu W/cm^2$ of the measured wavelength between 350 and 550 nm, peaking in sensitivity at 450 nm which is at the blue end of the visible spectrum.

*General Diagnostics, Morris Plains, New Jersey.

Results

The photodecomposition of the standard bilirubin

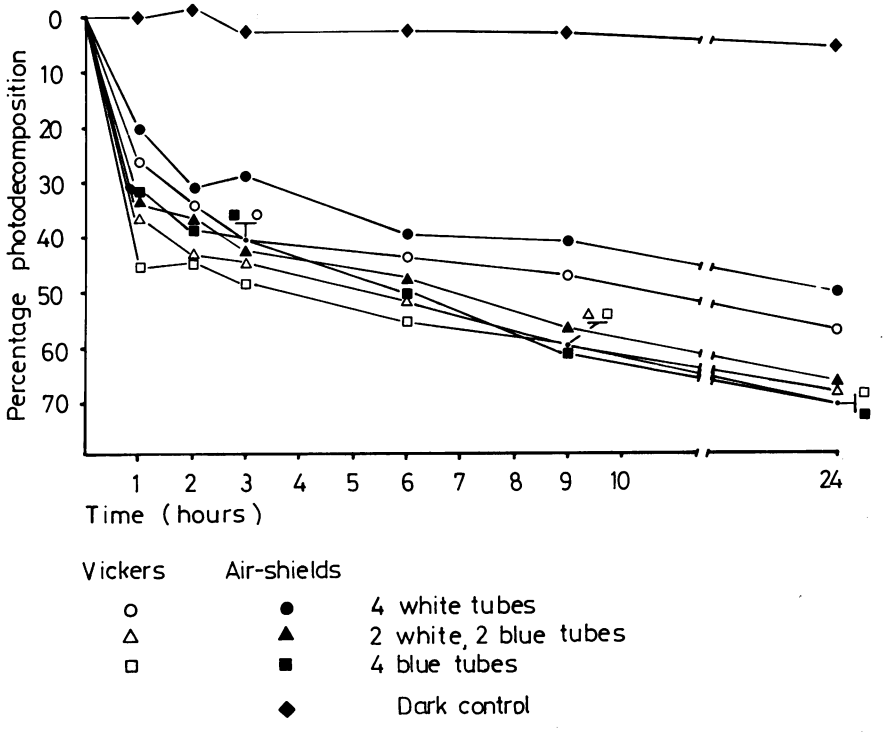

Fig. 1 *Percentage photodecomposition of bilirubin per unit time for various combinations of tubes in two phototherapy units.*

solution is expressed as a percentage reduction of the amount present at zero time (Fig. 1). The control solution left in the incubator, but not exposed to light, showed negligible photodecomposition in 24 hours. There was no significant difference in bilirubin reduction between the four white tubes in the phototherapy units at 24 hours ($P<0\cdot25$), nor was there any difference between the combination of two blue and two white tubes, and four blue tubes ($P<0\cdot1$). There was however a significant difference between the white tubes and any combination of blue, or blue and white tubes ($P<0\cdot001$).

The efficiency of the tube combination is derived from the following formula:[1]

Efficiency ratio = percentage bilirubin decomposed per 24 hours/radiant flux (irradiance)

In Fig. 2 the efficiency ratios of the two units are compared. There was no difference between the Vickers and the Air-Shields units with white tubes, but there were large differences between the efficiency ratio of the blue tubes in these two units, and also for the blue and white tube combination. In both instances the Vickers was more efficient than the Air-Shields unit ($P<0\cdot001$), in that less radiant flux was required for the same decline in bilirubin.

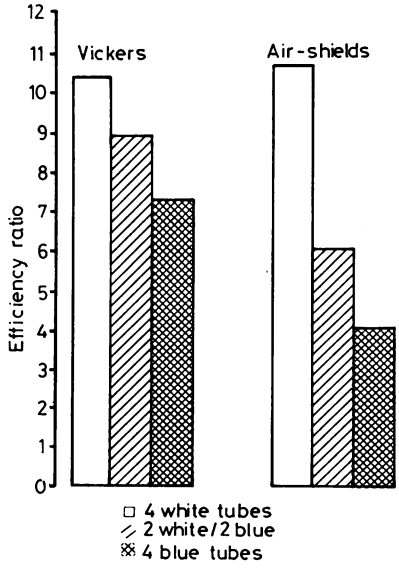

Fig. 2 *A comparison of the efficiency ratio of two phototherapy units.*

Discussion

Jaundiced sera from infants with hyperbilirubinaemia and artificially jaundiced model sera showed maximum absorption of light between 450 and 460 nm[2] which agrees closely with the observations that blue light in this range is most efficacious in photodegradation of bilirubin.[3] The effect of photodegradation of bilirubin *in vivo* is well known, and there is evidence that the *in vitro* serum model has the same reaction, provided that a physiological solution is used.[4] The jaundiced model sera used in this study contained appropriate amounts of albumin and remained well within the bilirubin-stable pH required and should have reflected the *in vivo* state.

Fig. 1 shows that the decline of bilirubin in white light was less effective than that of a combination of white and blue tubes, or pure blue only. There appears to be no advantage in using four blue tubes as opposed to a combination of two blue and two white tubes. Intense blue light is not liked by the staff of neonatal nurseries as it can cause nausea, headaches, and dizziness;[5] it also gives the baby an abnormal colour, making the detection of cyanosis difficult. The combination of blue and white light gives the infant a more acceptable colour and disturbs the staff less.

The Vickers phototherapy unit is clearly better at degrading bilirubin. Less light energy in the measured range is required to produce the same effect in decline of bilirubin. The principle of exposing any patient to the lowest possible radiation, even if the radiation is in the form of light energy, is an important one. The complications of phototherapy include potential long-term harm, and accurate recordings of periods of exposure to light and the radiant flux of the light energy should be made.

There is a linear relationship between bilirubin breakdown and the degree of light energy used in clinical phototherapy.[6] The Air-Shields unit however provides more light energy in the 450 nm wavelength than the Vickers for the all blue, and blue and white combinations. The degree of bilirubin breakdown however is no better than the Vickers unit, suggesting that another wavelength may also be contributing to the bilirubin decay. A small absorption peak at 420 nm has been found in jaundiced neonatal skin[7] and this may account for this disparity. It has not been possible to measure and compare the emission spectra of the two units to see if the Vickers device has a broader range over the wider bilirubin-sensitive spectrum.

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References

1. Ente G, Lanning E W, Cukor P, Klein R M. Chemical variables and new lamps in phototherapy. *Pediatr Res* 1972; **6**: 246–51.
2. Blondheim S H, Lathrop D, Zabriskie J. Effect of light on the absorption spectrum of jaundiced serum. *J Lab Clin Med* 1962; **60**: 31–9.
3. Bonta B W, Warshaw J B. Importance of radiant flux in the treatment of hyperbilirubinemia: failure of overhead phototherapy units in intensive care units. *Pediatrics* 1976; **57**: 502–5.
4. Sisson T R C, Kendall N, Davies R E, Berger D. Factors influencing the effectiveness of phototherapy in neonatal hyperbilirubinemia. *Birth Defects* 1970; **6**: No. 2, 100–5.
5. Sisson T R C, Kendall N. Letter: Avoidance of undesirable effects of blue light in phototherapy. *J Pediatr* 1973; **82**: 163–4.
6. Mims L C, Estrada M, Gooden D S, Caldwell R R, Kotas R V. Phototherapy for neonatal hyperbilirubinemia —a dose response relationship. *J Pediatr* 1973; **83**: 658–62.
7. Rubaltelli F F, Carli M. The effect of light on cutaneous bilirubin. *Biol Neonate* 1971; **18**: 457–62.

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Acute water intoxication as another unusual manifestation of child abuse

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SUMMARY A 4½-year-old boy developed hyponatraemia with coma and convulsions as the result of acute water intoxication. Information subsequently obtained strongly suggested that the excessive water ingestion was enforced by a punitive foster father.

It is known that child abuse can take many different forms. Kempe[1] listed some of the rarer manifestations of this disorder and asked that others should be reported so as to improve clinical acumen in this difficult field. He quoted, among other manifestations, hypernatraemic dehydration in older children, caused by a psychotic parent withholding