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Original Article

Effectiveness of phototherapy with reflecting curtains on neonatal jaundice

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Abstract

Background Although phototherapy has been used in clinical practice for 40 years, there is still much debate on how to provide the most efficacious phototherapy. Phototherapy with white reflecting curtains may increase the average spectral irradiance provided, as well as decrease serum bilirubin concentrations at a faster rate in neonates with jaundice.

Objective To determine if adding low cost, white, reflecting curtains to a standard phototherapy unit can increase the effectiveness of phototherapy for neonatal jaundice.

Methods A randomized, controlled, open trial was conducted at H. Adam Malik and Pirngadi Hospitals, Medan, from May to December 2009. The criteria for inclusion in the study were full term newborns with neonatal jaundice presenting in their first week of life. Single phototherapy with white curtains hanging from the sides of the phototherapy unit (study group, n=30) was compared to single phototherapy without curtains (control group, n=30). The primary outcomes measured were the mean difference in total serum bilirubin levels and average spectral irradiation levels measured at baseline, and after 12 hours and 24 hours of phototherapy.

Results The sum of average spectral irradiance in the curtained phototherapy unit was significantly higher than that of the standard phototherapy unit without curtains ($P < 0.05$). The decrease of total serum bilirubin levels after 12 and 24 hours of phototherapy was significantly greater in the study group (3.71 and 9.7 mg/dl, respectively) than in the control group (0.1 and 3.8 mg/dl, respectively), both $P < 0.05$.

Conclusion White, reflecting curtains in phototherapy units was significantly more effective than phototherapy without curtains for treatment of neonatal jaundice. **[Paediatr Indones. 2011;51:256-61]**.

Keywords: *neonatal jaundice, white reflecting curtains, spectral irradiance, phototherapy, bilirubin*

The American Academy of Pediatrics reported on the efficacy of phototherapy as a treatment for neonatal hyperbilirubinaemia.[1] Despite the long period of development since the original paper of Cremer *et al*[2], there are still considerable variations in spectral output, irradiance levels, and irradiated area provided by commercial phototherapy systems, as noted in the American Academy of Pediatrics report.[3] It is clear that irradiance is an important factor, with several studies showing that increased irradiance produces a faster decrease of serum bilirubin levels.[4]

A dose-response relationship exists between the amount of irradiation and reduction in serum bilirubin, up to an irradiation level of 30-40 μW/cm^2/nm. Newer phototherapy units, when properly configured, and the use of reflecting curtains may deliver light energy up to 40 μW/cm^2/nm, suggested to be the saturation level.[5] Single phototherapy with low cost, white, reflecting curtains may be more

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effective than single phototherapy alone, providing a less expensive alternative to double phototherapy for treatment of infants with jaundice.[6]

We aimed to compare the spectral irradiance and decrease in serum bilirubin levels in neonates using single phototherapy without curtains to those using single phototherapy with white, reflecting curtains.

Methods

We conducted a randomized, controlled, open clinical trial in Haji Adam Malik and Pirngadi Hospitals, Medan, Indonesia in May to December 2009. All babies admitted to the special care nursery of both hospitals during the study period, with uncomplicated neonatal jaundice and requiring phototherapy, were eligible for the study. Subjects were included by simple randomization. The need for phototherapy was determined using the American Academy of Pediatrics guidelines for management of jaundice in healthy term newborns. We excluded babies with serum bilirubin levels close to the exchange transfusion limit, elevated direct bilirubin, hemolytic disease and congenital anomalies. This study was approved by the Medical Ethics Committee, University of Sumatera Utara Medical School.

Sample size needed was estimated to be 30 neonates for each group. The following demographic and laboratory data obtained included age, sex, hemoglobin and albumin levels. Neonates were randomized to receive either single phototherapy without curtains (control group) or single phototherapy with white curtains around the sides of the phototherapy units. The white curtain and plastic were hung around the phototherapy unit. Light intensity was measured as spectral irradiance ($\mu W/cm^2/nm$) using a Dale 40 light intensity meter (Dale 40, USA).

Phototherapy units were manufactured by Tessna, USA (Tessna phototherapy unit with five compact blue fluorescent lamps). The distance between the phototherapy unit and the infant was standardized at 45 cm. Serum bilirubin and spectral irradiance were measured at baseline, and after 12 hours and 24 hours of phototherapy. The safety of both methods was assessed and compared by monitoring body temperature, hydration status (monitored clinically and by weight), skin problems (such as rashes) and gastrointestinal problems (such as loose stools or feeding intolerance).

The association between phototherapy type and serum bilirubin levels was analyzed by Student's t-test. Spectral irradiance was analyzed by comparing means with the Mann-Whitney U test. We analyzed data with

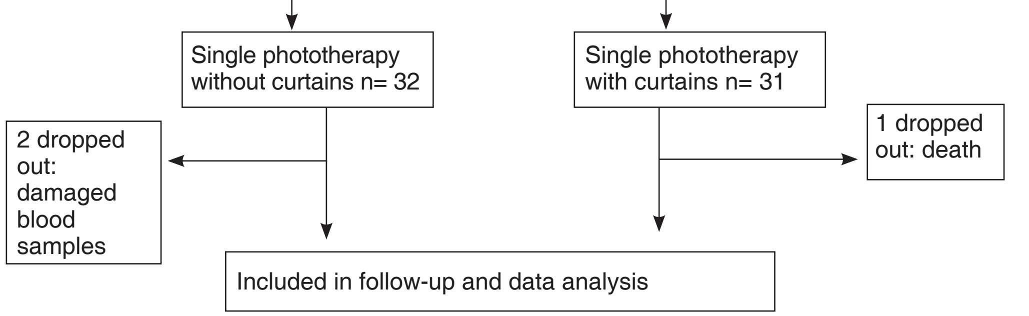

Figure 1. Study profile

SPSS version 14.0. The significance level was accepted as $P < 0.05$, with 95% confidence intervals (95% CI).

Results

We evaluated 72 neonates with hyperbilirubinemia. Nine neonates were excluded (4 with direct hyperbilirubinemia, 3 with congenital anomalies and 2 infants' parents did not consent). The remaining 63 enrolled in our study. Three babies were excluded from the final analysis as one from the intervention group died and two from the control group had damaged blood samples **(Figure 1).**

Both groups had similar characteristics at baseline including age, sex, weight, temperature, serum bilirubin, albumin and hemoglobin levels **(Table 1).**

There was no significant decrease in total serum bilirubin after 12 hours of phototherapy without curtains (P > 0.05). However, there was a significant decrease in total serum bilirubin after 12 hours of phototherapy with white, reflecting curtains, (P < 0.05), as shown in **Table 2.**

Table 3 shows significantly greater decrease in bilirubin levels in the single phototherapy with curtains group at 12 hours and 24 hours of phototherapy compared to single phototherapy without curtains (P < 0.05).

The spectral irradiance at the start, 12 and 24 hours was significantly different between single phototherapy with curtains and without curtains (P<0.05).

We monitored subjects for adverse effects of treatment. Hyperthermy (T>37.5ºC) was experienced by 5 subjects (8.3% of total), 3 in the single phototherapy with curtains group and 2 in the single phototherapy without curtains group. Other potential side effects, such as diarrhea and dehydration, were not observed during the study period.

Table 1. Baseline characteristics of subjects

	Intervention group(n=30)	Control Group (n=30)
Sex, male/female	15/15	17/13
Mean age, days (SD)	5.0 (1.36)	4.9 (1.34)
Mean weight, grams (SD)	2761.4 (203.70)	2720.3 (180.80)
Mean temperature, 0C (SD)	36.9 (0.31)	36.8 (0.27)
Mean total serum bilirubin before phototherapy, mg/dL (SD)	18.7 (1.81)	17.7 (1.45)
Mean albumin, g/dL (SD)	2.9 (0.22)	2.7 (0.13)
Hemoglobin, g/dL (SD)	14.0 (1.72)	14.0 (1.00)

Table 2. Mean decrease in total serum bilirubin after 12 hours and 24 hours of phototherapy in the two groups, with and without curtains

Type of phototherapy	Mean (SD)	95% CI	P
After 12 hours without curtains, mg/dl	0.1 (0.01)	- 0.0 to 0.1	0.059
After 24 hours without curtains, mg/dl	3.8 (1.35)	3.5 to 4.5	0.0001
After 12 hours with curtains, mg/dl	3.8 (0.91)	3.4 to 4.0	0.0001
After 24 hours with curtains, mg/dl	9.7 (1.42)	6.9 to 7.9	0.0001

Table 3. Bilirubin levels in both groups at baseline and after 12 and 24 hours of phototherapy

	Phototherapy with curtains	Phototherapy without curtains	95% CI	P
Mean initial bilirubin, mg/dL (SD)	18.7 (1.81)	17.7 (1.45)	0.06 to 1.76	0.38
After 12 hours	14.9 (1.98)	17.6 (1.44)	-3.62 to -1.83	0.0001
After 24 hours	9.0 (2.24)	13.9 (1.85)	-5.50 to -3.59	0.0001

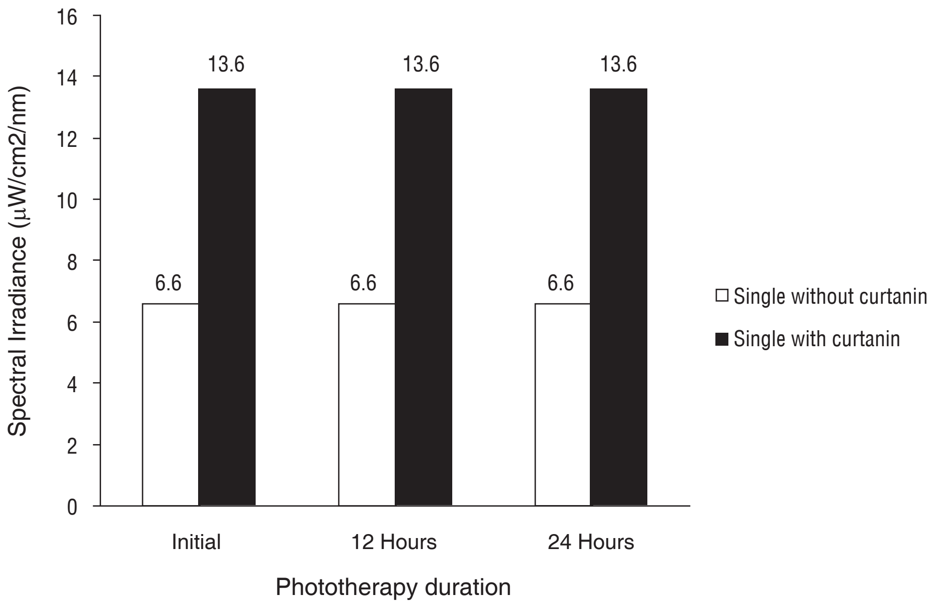

Figure 2. Spectral irradiance in both groups of phototherapy

Discussion

Phototherapy is the use of visible light for the treatment of hyperbilirubinemia in newborns. This relatively common therapy lowers serum bilirubin levels by transforming bilirubin into water soluble isomers that can be eliminated without conjugation in the liver. The dose of phototherapy largely determines how quickly this process can occur. The dose is determined by the wavelength of light, the intensity of the light, the distance between the light and the infant and the body surface area exposed to light (irradiance).[7,8]

Our results showed that the use of white curtains on the sides of phototherapy units can safely increase the efficacy of phototherapy. This simple and inexpensive method may be of great use to neonatal units in developing countries, where acquisition and maintenance of a sufficient number of phototherapy units may challenge limited budgets.

The reduction of bilirubin after 12 and 24 hours of phototherapy in the single phototherapy with curtains group was clearly greater than in the single phototherapy without curtains group. The reason for this finding was most likely due to the increased surface area exposed to phototherapy since the white curtains reflected light, leading to increased bilirubin decomposition.[7]

Our study results were consistent with a Malaysian study using single phototherapy with and without white reflecting curtains. They found bilirubin reduction after 4 hours of single phototherapy with curtains and without curtains to be 1.62 mg/dL vs 0.23 mg/dL, respectively. We observed the reduction of serum bilirubin after 12 hours of single phototherapy with curtains and without curtains to be 3.8 mg/dL vs 0.1 mg/dL, respectively. Their serum bilirubin reduction rate was 0.4 mg/dL/h, whereas ours was 0.3 mg/dL/h.[6]

Irradiance is the light intensity or number of photons delivered per square centimeter of exposed body surface. The delivered irradiance determines the effectiveness of phototherapy in that higher irradiance causes faster decline in serum bilirubin levels. Spectral irradiance quantified as $\mu W/cm^2/nm$, largely depends on the design of the light source. It can be measured with a spectral radiometer sensitive to the effective wavelength of light.[9,10]

In our study, spectral irradiance of single phototherapy with curtains was approximately 2 times greater than that of single phototherapy without curtains. The Malaysian study found spectral irradiance of single phototherapy with white reflecting curtains to be approximately 1.5 times that of single phototherapy without curtains.[11]

Blue light with a wavelength of 425 - 475 nm is best for lowering levels of indirect bilirubin. Several clinical trials showed that blue light was better at reducing bilirubin levels compared to light at other wavelengths.[11,12] Blue light has a shorter wavelength than visible light, other than violet light. Since wavelength is inversely proportional to energy, shorter wavelength will produce greater energy, thus reducing bilirubin levels at a faster rate than other light.[13] We used blue light and measured its intensity at baseline, 12 hours and 24 hours of phototherapy in both groups. There were significant differences in spectral irradiance with and without white reflecting curtains, ($P< 0.05$).

Neonates treated for high bilirubin levels may also suffer from dehydration and may require additional fluid intake.[14] Increased body and environmental temperature, insensible water loss, respiratory rate and blood flow to the skin are determined by neonatal maturity, adequate caloric intake, temperature of the phototherapy unit, distance between the neonate and the photolight, as well as the incubator heat loss. Increased blood flow to the periphery can increase fluid loss, requiring adjustment of intravenous fluids.[15,16] Changes in skin such as rashes, darker skin colour and burns may occur if neonates are over-exposed to fluorescent light.[15]

A study in the Netherlands found that during intensive phototherapy, a 20% increment of total fluid requirement can prevent increased body temperature.[17] During this study, body temperature and fluid administration were strictly monitored, with fluids given every 2 hours.

For breastfed neonates, phototherapy was stopped temporarily while the infant was fed by the mother.[18,19] We observed none of the negative effects mentioned above, but hyperthermy ($T > 37.5$ ºC) was observed in 3 (5% of total subjects) neonates in the single phototherapy with curtains group and in 2 (3.3% of total subjects) neonates in the single phototherapy without curtains group.

A previous study noted a strong association between breastfeeding and hyperbilirubinemia in healthy newborns during the first week of life. Phototherapy effectively reduced bilirubin levels in breastfed newborns with hyperbilirubinemia, but these patients showed a significantly slower response to treatment than that of mixed-fed newborns.[20] A limitation of our study was that we did not differentiate between breastfed and formula-fed neonates.

The evidence that phototherapy with simple white curtains hung on sides of phototherapy units is more effective than phototherapy without curtains is quite strong. This finding may translate into potential cost reductions in two ways. First, shorter duration of treatment means that more patients can be treated with fewer phototherapy units, resulting cost savings from decreased acquisition and maintenance of phototherapy units. Second, shorter duration of treatment would shorten the length of hospitalization. These advantages would be of major importance in developing countries, but are also valid for developed countries, where cost effectiveness is becoming increasingly important.

We demonstrated that single phototherapy with white reflecting curtains was more effective than single phototherapy without curtains in reducing serum bilirubin levels in term infants with hyperbilirubinemia, at the 12 and 24 hour measurement periods. In addition, spectral irradiance produced by single phototherapy with white, reflecting curtains was higher than that of single phototherapy without curtains.

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