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Original Article

# Phototherapy for neonatal jaundice at distances of 20 cm vs 40 cm

**Winra Pratita, Supriatmo, Guslihan Dasa Tjipta**

## Abstract

***Background*** Neonatal jaundice is one of the most common problems in newborns. Phototherapy is the most widespread treatment for lowering bilirubin concentration in neonates. Phototherapy may be more effective if the light source is placed closer to the neonate.

***Objective*** To compare the effectiveness of phototherapy with a 20 cm distance between the light source and the neonate vs a 40 cm distance for decreasing serum bilirubin concentration

***Methods*** An open, randomized, controlled trial was conducted at H. Adam Malik and Pirngadi Hospitals in Medan from August 2009 to March 2010. Subjects were divided into two groups. One group (n=30) received phototherapy at a distance of 20 cm between the light source and the neonate, while the other group (n=30) received phototherapy at a distance of 40 cm. The inclusion criteria in the study were newborns presenting with neonatal jaundice in their first week of life. Serum bilirubin levels were measured at baseline, as well as after 12 hours and 24 hours of phototherapy.

***Results*** The mean total bilirubin levels of the 20 cm and 40 cm groups at baseline were 18.8 (SD 1.73) mg/dL and 17.7 (SD 1.46) mg/dL, respectively, not significantly different. After 24 hours of phototherapy, the mean decreases in total serum bilirubin levels of the 20 cm and 40 cm groups were significantly different with 7.6 (SD 1.01) mg/dL and 2.0 (SD 0.83) mg/dL, respectively, ($P<0.05$).

***Conclusion*** Phototherapy with a 20 cm distance between the light source and the neonate is more effective than a 40 cm distance for decreasing bilirubin levels at 24 hours in newborns with hyperbilirubinemia. **[Paediatr Indones. 2013;53:278-82.]**.

***Keywords:*** *neonatal jaundice, phototherapy, distance, bilirubin*

Hyperbilirubinemia is a common and, in most cases, benign problem in neonates.[1] The bilirubin level in all newborn infants, term or premature, increases in the few days after birth.[2] Hyperbilirubinemia can progress to complications such as encephalopathy (kernicterus), although this is rare.[3] Jaundice is the visible manifestation of elevated serum concentrations of bilirubin in the skin and sclera.[4] Clinical jaundice is visible when the serum bilirubin level reaches 5 – 7 mg/dL, so it is necessary to use another objective parameter to detect hyperbilirubinemia in healthy term newborns before we measure serum bilirubin level.[3]

Ten percent of term infants and 25% of near-term infants have significant hyperbilirubinemia requiring phototherapy.[5] Phototherapy has remained the standard of care for hyperbilirubinemia treatment of infants for four decades. Efficient phototherapy rapidly reduces serum bilirubin concentration.[6] The efficacy of phototherapy is influenced by the following

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From the Department of Child Health, University of Sumatera Utara Medical School, H. Adam Malik Hospital, Medan , Indonesia.

**Reprint requests to:** Winra Pratita, Department of Child Health, University of Sumatera Utara Medical School, H. Adam Malik Hospital. Jl. Bunga Lau No. 17 Medan. Tel. +62-61-8361721, +62-61-8365663, Fax. +62-61-8361721. E-mail: wien_ra@yahoo.com.

factors: the wavelength delivered, the irradiance of the phototherapy, and the infant surface area exposed to phototherapy.[4] Placing the light source closer to the infant may increase the irradiance of overhead phototherapy systems.[7]

Our study aimed to compare the effectiveness of phototherapy at a 20 cm distance between the light source and the neonate to phototherapy with a 40 cm distance for decreasing total serum bilirubin levels.

## Methods

This randomized, open-label, controlled trial was conducted between August 2009 and March 2010 at H. Adam Malik and Pirngadi Hospitals, Medan, North Sumatera, Indonesia. Term newborns with total serum bilirubin levels above 10 mg/dL and preterm newborns with total serum bilirubin level above 12 mg/dL, who presented with neonatal jaundice in the first week of life were eligible for the study. Exclusion criteria were as follows: multiple congenital anomalies, birth weight below 1000 grams, direct hyperbilirubinemia, term newborns with serum bilirubin level ≥25 mg/dL and preterm newborns with serum bilirubin level ≥17 mg/dL. Informed consent was obtained from subjects' parents or guardians.

After enrollment, participants were randomly assigned to receive phototherapy at either a 20 cm distance or a 40 cm distance. The phototherapy units were manufactured by *Tessna, USA* (Tessna phototherapy unit with five compact blue fluorescent lamps) with wavelength 452-475 nm.

All infants who received phototherapy were placed in bassinets. The safety of both methods was assessed and compared by monitoring subejcts' body temperature, hydration status (monitored clinically and by weighing), skin problems (such as rashes) and gastrointestinal problems (such as loose stools or feeding intolerance). Phototherapy was stopped if we found dehydration, hyperthermia, lethargy, irritability or serum bilirubin level decreased more than 2 mg/dL compared to the serum bilirubin level limit for phototherapy.

Total serum bilirubin level and light intensity were measured at baseline, as well as after 12 hours and 24 hours of phototherapy. Light intensity was measured as spectral irradiance ($\mu W/cm^2/nm$) using a light intensity meter (*Dale 40*, USA).

The minimum sample size required was estimated to be 30 newborns for each group. The significance level was accepted as $P<0.05$ with a 95% confidence interval (95% CI). Numerical variables were compared using ANOVA. Independent t-test was used to compare the reductions in total serum bilirubin levels.

This study was approved by Medical Ethics Committee at the University of North Sumatera Medical School.

## Results

Of the 67 newborns with neonatal jaundice in the first week of life, 4 newborns' parents/guardians refused to participate in the study. Of the 63 newborns enrolled, 31 newborns received phototherapy from a 20 cm distance while the other 32 newborns received phototherapy from a 40 cm distance. Three infants (one from the 20 cm group and two from the 40 cm group) were excluded from the final analysis because of broken blood specimens tubes (**Figure 1**). The baseline characteristics of subjects are shown in **Table 1**.

**Table 1**. Baseline characteristics of subjects

| Characteristics | 20 cm group (n=30) | 40 cm group (n=30) |
|---|---|---|
| Gender, n | | |
| Males | 13 | 17 |
| Mean age at start of phototherapy (SD), days | 4.9 (1.16) | 4.9 (1.35) |
| Mean body weight (SD), grams | 2,841.7 (190.77) | 2,720.0 (180.80) |
| Mean body temperature (SD), ºC | 37.0 (0.27) | 36.8 (0.28) |
| Mean bilirubin level (SD), mg/dL | 18.8 (1.73) | 17.7 (1.46) |
| Mean albumin level (SD), g/dL | 3.0 (0.24) | 2.8 (0.17) |
| Mean haemoglobin level (SD), g/dL | 14.2 (0.91) | 14.0 (1.03) |

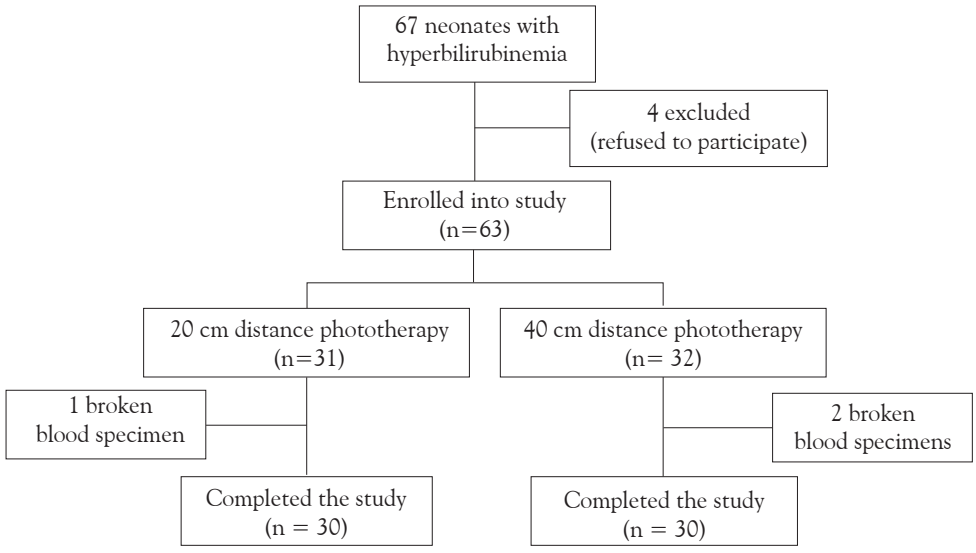


**Figure 1**. Study profile

During follow up (**Table 2**), total serum bilirubin at 12 hours and 24 hours were significantly different between the groups (P=0.001). On both follow-up time points, we found lower serum bilirubin levels in the 20 cm distance phototherapy group.

The decreases in total serum bilirubin levels at follow-up were greater in the 20 cm group than in the 40 cm group, at both 12 and 24 hours (P=0.001). In the 20 cm distance phototherapy group, we also noted an greater decrease in total serum bilirubin (**Table 3**).

In our study, the light intensity was 13-14 $\mu$W/cm$^2$/nm for the 20 cm group and 6-7 $\mu$W/cm$^2$/nm for the 40 cm group.

## Discussion

Hyperbilirubinemia is the most common health problem during the early neonatal period.[3] Jaundice is observed during the first week of life in approximately 60% of term infants and 80% of preterm infants.[1] Most jaundice is benign, but because of the potential toxicity of bilirubin, newborn infants must be monitored to identify those who might develop severe hyperbilirubinemia and, in rare cases, acute bilirubin encephalopathy or kernicterus.[8]

In our study, we used phototherapy as a treatment to reduce total serum bilirubin in neonatal jaundice patients. Phototherapy is now the preferred method of

**Table 2**. Mean serum bilirubin levels after 12 and 24 hours of phototherapy

| | 20 cm group (n=30) | 40 cm group (n=30) | P value |
|---|---|---|---|
| At 12 hours (SD), mg/dL | 15.0 (1.65) | 17.6 (1.44) | 0.001 |
| At 24 hours (SD), mg/dL | 11.2 (1.77) | 15.7 (1.51) | 0.001 |

**Table 3**. Decreases in mean serum bilirubin level after 12 and 24 hours of phototherapy

| | 20 cm group (n=30) | 40 cm group (n=30) | P value |
|---|---|---|---|
| 0 to 12 hours (SD), mg/dL | 3.8 (0.71) | 0.1 (0.17) | 0.001 |
| 12 to 24 hours (SD), mg/dL | 3.8 (0.77) | 1.9 (0.82) | 0.001 |
| 0 to 24 hours (SD), mg/dL | 7.6 (1.01) | 2.0 (0.83) | 0.001 |

treatment for neonatal hyperbilirubinemia by virtue of its noninvasive nature and its safety.[9] Phototherapy also converts native bilirubin, by an irreversible reaction, to the structural isomer lumirubin, which is excreted by the kidneys in the unconjugated state.[1]

We found that the spectral irradiance produced by phototherapy at a 20 cm distance between the light source and the neonate was approximately 2 times greater than phototherapy at a 40 cm distance. The light intensities were 13-14 $\mu$W/cm$^2$/nm and 6-7 $\mu$W/cm$^2$/nm, for 20 cm and 40 cm distance phototherapy groups, respectively. A previous study found that the rate of bilirubin decline was proportional to light intensity, suggesting that phototherapy of higher intensity would increase effectiveness.[9] The efficacy of phototherapy depends on the irradiance of the light source. Irradiance is measured with a radiometer or spectroradiometer in units of watts per square centimeter or in microwatts per square centimeter per nanometer.[10] The American Academy of Pediatrics defines intensive phototherapy as a spectral irradiance of at least 30 $\mu$W per square centimeter per nanometer over the same bandwith delivered to as much of the infant's body surface area as possible.[2,8,10] Multiple phototherapy units and the use of reflecting curtains in phototherapy are used to increase the light intensity and thus improve the efficacy of phototherapy.[11] Conventional phototherapy involves exposing a maximal area of skin to an irradiance of 6 to 12 $\mu$W/cm$^2$/nm.[4]

In the present study, we used blue light phototherapy units with wavelength 452-475 nm. Other studies have reported that the bilirubin molecule, responsible for the yellow skin color of jaundiced babies, was most sensitive to light in the blue and blue-green regions of the visible spectrum.[12] Bilirubin is a yellow pigment, and most likely to absorb blue light at approximately 450 nm.[6,13] For treatment of hyperbilirubinemia, light in the range of approximately 400-500 nm with a peak at 460 ± 10 nm, is considered the most effective.[14]

The efficacy of phototherapy depends on irradiance (light intensity), the quality of light (optimal in the blue-green region of the wavelength at 400-500 nm), the distance of the light source from the infant, the surface area of the infant exposed to light, and the duration of exposure.[15,16]

In our study, the infants wore only diapers and eye patches during phototherapy. An infant being treated with phototherapy is placed in the bassinet (preferably naked) with eyes shielded.[6] To maximize the dose at a given irradiance, infants are routinely nursed naked while receiving conventional overhead phototherapy. Information about the efficacy of the dose response effect of phototherapy by increasing skin surface area exposure has been derived from several studies.[17,18]

In our study, infants were put in bassinets at a distance of 20 cm or 40 cm from the light sources. The total serum bilirubin levels were measured at baseline, 12 hours and 24 hours of phototherapy in both groups with significantly different decreases in levels. The reduction of bilirubin after 12 hours of phototherapy in the 20 cm group was significantly greater than that of the 40 cm group. Our results suggest that nearer distance phototherapy may safely increase the treatment efficacy. There is a direct relationship between the irradiance used and the rate at which the level of total serum bilirubin declines.[10] The light intensity (measured as spectral irradiance) is inversely related to the distance from the source. The relationship between intensity and distance was shown to be almost linear.[19] Placing the lamps 15 – 20 cm from the infant increased the surface area.[1] Increasing the surface area exposed to phototherapy will significantly improve its efficacy. Past studies reported that the infant must be in a bassinet, not an incubator, so that the light can be brought to within 10 cm of the infant.[2,8] In a study in Iran, the 20 cm distance between the light source and the skin surface provided a rapid and more effective bilirubin reduction with a shorter duration of phototherapy than that of 40 cm distance, probably due to higher spectral irradiance in neonates.[20]

We observed no side effects of phototherapy in our subjects at a 20 cm distance from the light source. Exposure from a 20 cm distance was well-tolerated and no significant differences between the two groups were observed in terms of phototherapy side effects, such as troublesome skin rashes, burns, clinical dehydration, or lethargy.[20] Another study reported that naked term infants did not become overheated at a 10 cm distance from the phototherapy light source.[8] During the study period, body temperature and fluid administration were strictly monitored. Fluid need was increased by up to 20% of the total fluid need. Temperature and hydration status should be monitored.[6] A Dutch

study found that during intensive phototherapy, a 20% increment of total fluid requirement may prevent increased body temperature.[21]

In conclusion, phototherapy at a 20 cm distance between the light source and neonate is more effective than phototherapy at a 40 cm distance for reducing serum bilirubin levels in term infants with hyperbilirubinemia.

## References


1. Stoll BJ, Kliegman RM. Jaundice and hyperbilirubinemia in the newborn. In: Behrman RE, Kliegman RM, Jenson HB, editors. Nelson textbook of pediatrics. 17th ed. Philadelphia: Saunders Elsevier; 2006. p. 592-8.
2. Maisels M. Neonatal hyperbilirubinemia. In: Polin A, Yodes MC, editors. Workbook in practical neonatology. 4th ed. Philadelphia: Saunders; 2007. p. 53-70.
3. Indriyani S, Retayasa IW, Surjono A, Suryantoro P. Percentage birth weight loss and hyperbilirubinemia during the first week of life in term newborns. Paediatr Indones. 2009;49:149-54.
4. Madan A, Macmahon JR, Stevenson DK. Neonatal hiperbilirubinemia. In: Taeusch HW, Ballard RA, Gleason CA, editors. Avery's disease of the newborn. 8th ed. Philadelphia: Saunders Elsevier; 2005. p. 1226-53.
5. Dewanto NE, Rohsiswatmo R. Management of hyperbilirubinemia in near-term newborns according to American Academy of Pediatrics Guidelines: report of three cases. Paediatr Indones. 2009;49:125-30.
6. Dennery AP, Seidman DS, Stevenson DK. Neonatal hyperbilirubinemia. N Engl J Med. 2001;344:581-90.
7. Hart G, Cameron R. The importance of irradiance and area in neonatal phototherapy. Arch Dis Child Fetal Neonatal Ed. 2005;90:F437-40.
8. American Academy of Pediatrics Subcommittee on Hyperbilirubinemia. Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. Pediatrics. 2004;114:297-316.
9. Al-Alaiyan S. Fiberoptic, conventional and combination phototherapy for treatment of nonhemolytic hyperbilirubinemia in neonates. Ann Saudi Med. 1996;16:633-6.
10. Maisels MJ, McDonagh AF. Phototherapy for neonatal jaundice. N Engl J Med. 2008;358:920-8.
11. Djokomulyanto S, Quah BS, Surini Y, Noraida R, Ismail NZ, Hansen TWR, *et al*. Efficacy of phototherapy for neonatal jaundice is increased by the use of low-cost white reflecting curtains. Arch Dis Child Fetal Neonatal Ed. 2006;91:439-42.
12. Wentworth SD. Neonatal phototherapy – today's lights, lamps and devices. Infant. 2005;1:14-9.
13. Seidman DS, Moise J, Ergaz Z, Laor A, Vreman HJ, Stevenson DK, *et al*. A new blue light-emitting phototherapy device: a prospective randomized controlled study. J Pediatr. 2000;136:771-4.
14. Vreman HJ, Wong RJ, Stevenson DK. Phototherapy: current methods and future directions. Semin Perinatol. 2004;28:326-33.
15. Frank GC, Cooper SC, Merenstein GB. Jaundice. In: Merenstein GB, Gardner SL, editors. Handbook of neonatal intensive care. 5th ed. Philadelphia: Mosby Elsevier; 2002. p. 443-59.
16. Vreman J, Hendrik J, Ronald JW, Stevenson, Roger KR, Sidney DR, *et al*. Light-emitting diodes: a novel light source for phototherapy. Wolters Kluwer Pediatrics Research. 1998;44:804-9.
17. Pritchard MA, Beller EM, Norton B. Skin exposure during conventional phototherapy in preterm infants: a randomized controlled trial. J Paediatr Child Health. 2004;40:270-4.
18. Boonyarittipong P. Effectiveness of double-surface intensive phototherapy versus single-surface intensive phototherapy for neonatal hyperbilirubinemia. J Med Assoc Thai. 2008;91:50-5
19. Maisels MJ. Phototherapy-traditional and nontraditional. J Perinatol. 2001;21:93-7.
20. Pishva N, Madani A. Effect of the different light–source distances from the skin surface in conventional phototherapy. IJMS. 2004;29:189-91.
21. Grunhagen DJ, de Boer MGJ, de Beaufort AJ. Transepidermal water loss during halogen spotlight phototherapy in preterm infants. Pediatr Res. 2002;51:402-5.