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Original Article

Effect of phototherapy with alumunium foil reflectors on neonatal hyperbilirubinemia

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Abstract

Background Neonatal hyperbilirubinemia (NH) is one of the most common problems in neonates, but it can be treated with blue light phototherapy. Developing countries with limited medical equipment and funds have difficulty providing effective phototherapy to treat NH, leading to increased risk of bilirubin encephalopathy. Phototherapy with white reflecting curtains can decrease the duration of phototherapy needed to reduce bilirubin levels.

Objective To compare the duration of phototherapy needed in neonates with NH who underwent phototherapy with and without aluminum foil reflectors.

Methods This open clinical trial was conducted from July to August 2013 at Dr. Hasan Sadikin Hospital, Bandung, Indonesia. The inclusion criteria were term neonates with uncomplicated NH presenting in their first week of life. Subjects were randomized into two groups, those who received phototherapy with or without aluminum foil reflectors. Serum bilirubin is taken at 12th, 24th, 48th hours, then every 24 hours if needed until phototherapy can be stopped according to *American Academy of Pediatrics* guidelines. The outcome measured was the duration of phototherapy using survival analysis. The difference between the two groups was tested by Gehan method.

Results Seventy newborns who fulfilled the inclusion criteria and had similar characteristics were randomized into two groups. The duration of phototherapy needed was significantly less in the group with aluminum foil reflectors than in the group without reflectors [72 vs. 96 hours, respectively, ($P<0.01$)].

Conclusion The required duration of phototherapy with aluminum foil reflectors is significantly less than that of phototherapy without reflectors, in neonates with NH. **[Paediatr Indones. 2015;55:18-22.]**

Keywords: *aluminum foil reflector, neonatal hyperbilirubinemia, phototherapy*

Neonatal hyperbilirubinemia (NH) is one of the most common problems in newborns, affecting about 60% of term neonates and 80% of preterm neonates.[1,2] Phototherapy is the most common treatment used for NH. The efficacy of phototherapy depends on the phototherapy light source, light intensity, distance between the phototherapy light and the neonate, and light-exposed body surface area.[3-5] Previous studies from Malaysia and Indonesia showed that white reflecting curtains can increase the efficacy of phototherapy in neonates with NH.[6,7] In addition to white reflecting curtains, aluminum foil can reflect about 92–98% of light and wavelength, so it can be used as a reflector in phototherapy.

The aim of this study was to compare the duration of phototherapy needed in term neonates with NH who underwent phototherapy with and without aluminum foil reflectors.

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Methods

This open clinical trial was conducted in Dr. Hasan Sadikin Hospital, Bandung, from July to August 2013. All term neonates with uncomplicated NH and requiring phototherapy based on the *American Academy of Pediatrics* (AAP) guidelines[8] were included in this study. All neonates with NH onset at <24 hours of life, congenital anomalies, severe asphyxia, G_6PD deficiency, severe infection, or unknown birth weight, were excluded from this study. The minimum requred sample size was calculated using a formula to calculate difference of the two means with 95% confidence interval and 80% power test, resulting in an estimated 35 neonates for each group.

Subjects were selected by consecutive sampling based on neonates who were admitted for NH. They were divided into two groups by permutated block randomization, phototherapy with aluminum reflectors (intervention group) or phototherapy without reflectors (control group). Serum bilirubin is taken at 12th, 24th, 48th hours, then every 24 hours if needed until phototherapy can be stopped according to AAP guidelines. Subjects remained in their respective groups until phototherapy was stopped or the neonate was excluded from the study. Aluminum reflectors were placed on all four sides of the neonate's cot (**Figure 1**).

Figure 1. Set up for the intervention group using aluminum foil reflectors on all four sides of the neonatal cot

We used single, blue light phototherapy with a wavelength range of 460–490 nm. New blue light bulbs were put into the phototherapy unit in this study. The distance between the phototherapy unit and the neonate was standardized at 30 cm, based on AAP guidelines for delivering optimal spectral irradiance to decrease serum bilirubin levels. Subjects' vital signs and hydration status were monitored hourly during this study. Fluid intake was increased by 10% from the neonatal daily requirement.

The characteristics of subjects were analyzed by Chi-square test for category data and Anova test for numeric data. The durations of phototherapy with and without aluminum foil reflectors were analyzed by survival analysis method and significance level measured by Gehan test. The significance level was accepted as $P<0.05$.

The study was approved by the Research and Ethics Committee of the University of Padjadjaran Medical School, Indonesia, and written parental consent was obtained.

Results

We enrolled 70 neonates who fulfilled the inclusion criteria, with 35 neonates allocated to the control group and 35 neonates allocated to the intervention group. Characteristics of subjects are shown in **Table 1**.

Neonatal factors related to serum bilirubin levels such as feeding type, difference between birth weight and weight before the start of phototherapy, age at phototherapy onset, and initial serum bilirubin level were distributed similarly between groups (**Table 1**).

Serum bilirubin was monitored at 12th, 24th, 48th, 72nd, and 96th hours after phototherapy was started. All serum bilirubin in the intervention group decreased to off phototherapy level within 72 hours, compared to that of the control group which need 96 hours to reach off phototherapy level. (**Table 2.**)

Table 1. Baseline characteristics of subjects

Characteristics	Group	
	Phototherapy without reflectors (n= 35)	Phototherapy with aluminum foil reflectors (n= 35)
Gender, n		
Male	17	20
Female	18	15
Gestational age, weeks		
Mean (SD)	38.1 (0.8670)	38.0 (0.857)
Median	38.0	38.0
Range	37–39	37–40
Birth weight, grams		
Mean (SD)	2,953.1 (327.7)	2,964.3(355.9)
Median	2,860.0	2,900.0
Range	2,500–3,450	2,500–3,600
Feeding type		
Breast milk	18	21
Formula milk	10	9
Mixed	7	5
Weight difference between birth and onset of phototherapy, grams		
Mean (SD)	99.9 (74.0)	106.9 (72.2)
Median	100.0	100.0
Range	0–250	0–270
Percentage (%)	3.1	3.4
Age at phototherapy was started, hours		
Mean (SD)	101.4(32.7)	93.9 (30.3)
Median	104.0	96.0
Range	38–162	40–150
Initial serum bilirubin, mg/dL		
Mean (SD)	18.1 (3.0)	18.5 (3.1)
Median	17.8	18.2
Range	12.1–24.42	13.8–25.5

Duration of phototherapy in the intervention group was significantly less by 24 hours compared to that of the control group (**Figure 2**).

The survival analysis between phototherapy with and without aluminum foil reflectors is shown in **Figure 2.** The intervention group required 72 hours to stop all phototherapy, while the control group required 96 hours, a significant difference (P=0.01).

Discussion

We found that the duration of phototherapy with aluminum foil reflectors was less than that of phototherapy without reflectors. Neonatal factors related to serum bilirubin levels such as feeding type, difference between birth weight and weight at phototherapy onset, age at phototherapy onset, and initial serum bilirubin levels were similar in both groups. As such, those factors would not affect our survival analysis results.

The efficacy of phototherapy depends on the light source, light intensity, distance between the phototherapy unit and neonate, and optimal light-exposed skin surface area.[3-5] As such, one or more of these factors may have influenced the decreased duration of phototherapy with aluminum foil reflectors. We used single, blue light phototherapy with a wavelength range of 460–490 nm and a standardized 30 cm distance between the phototherapy unit and the neonate. According to AAP guidelines, phototherapy with wavelength range of 460–490 nm is most effective for decreasing serum bilirubin levels, due to its ability to penetrate tissue, in order to convert serum bilirubin to conjugated bilirubin for easier excretion.[3,-5] During the study, subjects wore only diapers and eye covers. The neonate's position was changed every 2–3 hours to maximize the surface area of light-exposed skin. As

Table 2. Serum bilirubin level after 12th, 24th, 48th, 72nd, and 96th hours of phototherapy

Duration of phototherapy, hours	Serum bilirubin levels		P value
	Phototherapy without reflector	Phototherapy with aluminum foil reflector	
12th	n= 35	n= 35	0.354
Mean (SD)	17.2 (2.8)	16.5 (3.2)	
Median	17 .0	16.5	
Range	12.8–23.0	9.7– 23.8	
24th	n= 35	n= 34	0.003
Mean (SD)	15.9 (2.7)	13.9 (2.6)	
Median	15.9	14.2	
Range	10.4–20.8	8.7–21.2	
48th	n= 34	n= 19	0.011
Mean (SD)	14.0 (2.5)	12.3 (2.2)	
Median	14.2	12.7	
Range	9.6–18.6	9.5–17.6	
72nd	n= 17	n= 4	0,062
Mean (SD)	13.8 (1.9)	11.6 (1.8)	
Median	14.1	11.0	
Range	10.4–16.8	10.1–14.2	
96th	n= 5	n= 0	
Mean (SD)	13.5 (1.6)	-	-
Median	14.4	-	
Range	11.7–14.9	-	

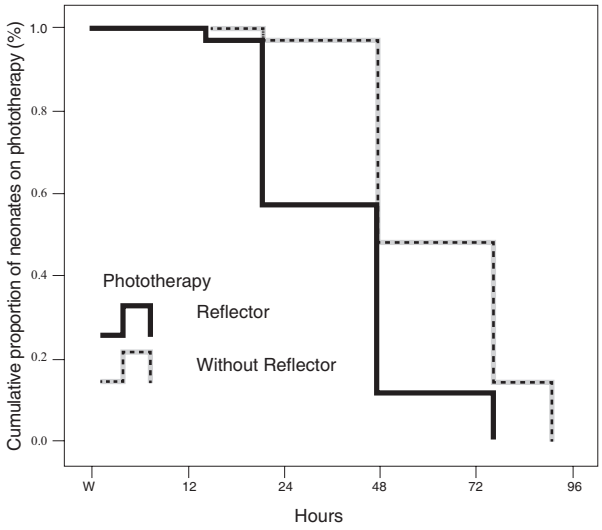

Figure 2. Cumulative proportion of duration phototherapy according to type of intervention (with and without aluminum foil reflectors)

the reflector acts to reflect light and wavelength, the body surface area exposed to light also increased.[3-5] The distance of 20–30 cm between the phototherapy unit and the neonate provides the most effective spectral irradiance to decrease serum bilirubin levels.[9] The reflector also increases phototherapy spectral irradiance.[9] Previous studies on phototherapy with reflectors in Kelantan (Malaysia) and Medan (Indonesia) used white reflecting curtains.[6,7] Results from both studies showed that white reflecting curtains increased the efficacy of phototherapy compared to phototherapy without reflectors. Both studies also showed that the phototherapy spectral irradiance with white reflecting curtains was 1.5–2 times greater than that of phototherapy without reflectors.[6,7]

By using aluminum foil as a reflector, about 92–98% of light is reflected, wavelength, and irradiance, and it resists corrosion.[10] Aluminum foil also is very thin and easy to fold into the desired shape. Since aluminum foil is silver, which is the "whitest" color, it will absorb and reflect all the light directly.[11,12] The advantages of aluminum foil compared to white curtains as reflectors include the less expensive price, the ease in making the reflectors, the simpler maintenance, and the lack of side effects. These advantages are important in developing countries as funds and medical equipment may be limited.

The limitation of this study was that subjects were only newborns with uncomplicated NH. Further study with complicated NH cases, such as NH caused by hemolytic conditions (ABO incompatibility, G_6PD deficiency, or preterm neonates) is needed to evaluate the effect of phototherapy with aluminum foil reflectors. The other limitations were that we

did not measure the phototherapy irradiance in either group using a spectroradiometer, and that we did not measure bilirubin level after phototherapy due to most of neonates were discharged soon as phototherapy was stopped.

In conclusion, the required duration of phototherapy with aluminum foil reflectors is less than that of phototherapy without reflectors, for NH treatment.

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