Ankara Üniversitesi Tıp Fakültesi Mecmuası 2007; 60(1)

Efficacy Of Light Emitting Diode Phototherapy In Comparison To Conventional Phototherapy In Neonatal Jaundice

Yenidoğan Sarılığında Yüksek Yoğunlukta Işık Yayan Diyot Fototerapilerinin Konvansiyonel Fototerapiye Göre Etkinliği

Belma Saygılı Karagöl, Ömer Erdeve, Begüm Atasay, Saadet Arsan

Ankara Üniversitesi Tıp Fakültesi Neonatoleji Bilim Dalı, Ankara

Objective: Phototherapy is the standard treatment for the control of neonatal hyperbilirubinemia. The purpose of this study was to compare the efficacy of light emitting diode (LED) device with respect to bilirubin photodegradation with commercially used conventional fluorescent tubes phototherapy device in hyperbilirubinemic neonates by measuring serum bilirubin levels.

Methods: Twenty hyperbilirubinemic neonates treated with conventional phototherapy (Group I) and 15 neonates treated with LED phototherapy (Group II) were retrospectively compared. Birth weight, gender, family history, etiology of jaundice, initiation time of phototherapy, total serum bilirubin (TSB) level at the initiation of the therapy and at 4,24 hours and the last TSB level before cessation of phototherapy, rebound serum bilirubin level obtained 24 hours of termination of phototherapy and duration of phototherapy were recorded. 'Absolute' change and 'relative' percantage change in serum bilirubin levels were also calculated.

Results: There were significant differences in the absolute change in serum bilirubin level per hour and relative change in serum bilirubin level at 24 hour between group I and group II ($p<0.05$). Rebound jaundice was observed in 4 (20%) of the neonates who received conventional phototherapy while it had not been seen in LED phototherapy group ($p= 0.006$). Duration of phototherapy was shorter in the LED phototherapy group but this was not statistically significant (43.1 vs 32.1hrs).

Conclusion: LED phototherapy was found to be more efficient as they can provide more rapid bilirubin photodegradation in terms of change in serum bilirubin level per hour of phototherapy and percentage change in serum bilirubin level per hour after 24 hours of treatment. The incidence of rebound hyperbilirubinemia with LED phototherapy seems to be less than conventional phototherapy and this may prevent unnecessary rebound bilirubin measurements in non-hemolytic jaundice

Key Words: hyperbilirubinemia, jaundice, light emitting diode, phototherapy,

Amaç: Fototerapi, yenidoğan hiperbilirubinemi kontrolünde standart tedavi yöntemidir. Bu çalışmanın amacı, hiperbilirubinemik yenidoğanlarda serum bilirubin düzeyi ölçülerek yüksek yoğunlukta ışık yayan diyot (LED) fototerapi ile geleneksel fototerapi etkinliğini karşılaştırmaktır.

Yöntem: Konvansiyonel fototerapi ile tedavi edilmiş 20 hiperbilirubinemik olgu (grup I) ile LED fototerapi uygulanan 15 hiperbilirubinemik olgu (grup II) doğum ağırlığı, cinsiyet, aile öyküsü, sarılık başlama zamanı ve etiyolojisi, fototerapi öncesi ve başlandıktan sonraki 4. ve 24. saatlerdeki serum total bilirubin düzeyi, fototerapi kesilmeden önceki son serum total bilirubin düzeyi, fototerapi kesildikten sonraki 24. saatinde bakılan rebound hiperbilirubinemi ve fototerapi süresi değerlendirildi. Olgular 'mutlak' bilirubin değişim oranı ve 'rölatif' bilirubin değişim yüzdeleri açısından da karşılaştırıldı.

Sonuç: İki grup arasında saatlik mutlak bilirubin değişim oranı ve 24. saatteki rölatif bilirubin değişim yüzdesinde anlamlı farklılık saptandı ($p<0.05$). LED fototerapi grubunda rebound sarılık görülmezken, konvansiyonel fototerapi uygulanan 4 olguda rebound sarılık gelişti ($p=0.006$). Fototerapi süresinin LED grubunda daha kısa olduğu gözlenmiş olmasına karşın, bu durum istatiksel olarak anlamlı bulunmadı (43.1 vs 32.1 saat).

Yorum: LED fototerapi hızlı bilirubin fotodegradasyonu nedeni ile saatlik bilirubin değişim oranı ve tedavinin 24. saatindeki bilirubin değişim yüzdesi bakımından daha etkili bulundu. Rebound hiperbilirubinemi insidansının LED fototerapide konvansiyonel fototerapiye göre daha az oranda olduğu ve bu durumun hemolitik olmayan sarılıklarda gereksiz rebound bilirubin ölçümünü önleyeceği düşünülmektedir.

Anahtar Sözcükler: hiperbilirubinemi, sarılık, yüksek yoğunlukta ışık yayan diyot, fototerapi,

Received: 02.12.2006 • *Accepted:* 30.12.2006

Corresponding author

Belma Saygılı Karagöl
Neonatoloji Bilim Dalı, 06100, Ankara
Tel : (312) 595 65 99
E-mail adress : belmakaragol@yahoo.com

Phototherapy is the standard treatment for the control of neonatal hyperbilirubinemia. Its efficacy is dependent on the color (wavelength) and intensity (irradiance) of the light emitted during phototherapy, the exposed body surface area and the duration of exposure (1). In the current guidelines of American Academy of Pediatrics (AAP), intensive phototherapy is defined as the use of blue light (in the 430-490 nm band) delivered at 30 microwatts/ cm^2/nm or higher to the greatest body surface area as possible (2). The most commonly used light sources are; fluorescent tubes, halogen spotlights and fiberoptic blankets. However; these conventionally used phototherapy devices are less effective and each of these devices has a number of disadvantages that include high heat production and only limited surface area exposure (3).

Recently, high intensity gallium nitride light emitting diodes (LEDs) have been developed and generated significantly higher light irradiance levels compared to all currently available conventional phototherapy units (4,5). Blue LEDs emit a high intensity narrow band of blue light overlapping the peak spectrum of bilirubin breakdown, resulting in potentially shorter treatment times (6,7). In the present study, we compared the efficacy of LED device (35 microwatts/cm^2/nm) with respect to bilirubin photodegradation with commercially used conventional fluorescent tubes phototherapy device (10-15 microwatts/cm^2/nm) by measuring serum bilirubin levels in hyperbilirubinemic neonates.

MATERIALS AND METHODS

We retrospectively classified two non-hemolytic hyperbilirubinemic neonate groups: 20 neonates who had been treated by conventional phototherapy (Group I) and 15 neonates who were treated by LED phototherapy. Term newborns who were older than 3 days were included to the study. Criteria defined by AAP were used to initiate and terminate the treatment (2). The infants were placed in open cribs, unclothed except for a diaper and had their eyes covered. Conventional fluorescent phototherapy was utilized in the control group with standart phototherapy units (Air-Shields Fluoro-Lite® Phototherapy System, Dräger Medical AG & Co. KG Aa Lübeck, Germany). At a standart distance of 40 cm, the

Table I. Patient characteristics and comparison of group I and group II

	Conventional Group I (n: 20)	**LED Group II** (n:15)	***p***
Birth weight (g)	3290± 464	3179±497	0.504
Cesarean section / vaginal	11 / 9	9 / 6	0.767
Gestational age	37.9±1.8	37.5±1.7	0.558
Gender (F/M)	13/7	9/6	0.552
Admission age (hour)	100.2±40	94.4±54	0.719
Baseline TSB (mg/dl)	17.6±4.5	19.6±3.3	0.155
TSB at 4 hour (mg/dl)	16.2±3.9	17.1±2.7	0.471
TSB at 24 hour (mg/dl)	14.8±3.4	14.4±2.1	0.668
Last TSB level (mg/dl)	12.8±2.8	12.4±1.9	0.687
Duration of phototherapy (hour)	43.1±21.4	32.1±14.6	0.097
*Absolute change in TSB per hour (mg/dl/hour)	0.13±0.1	0.30±0.2	**0.003**
•Relative change in TSB at 4 hour (%)	2.22±2.4	3.09±3.2	0.367
• Relative change in TSB at 24 hour (%)	0.54±0.6	1.06±0.3	**0.008**
Rebound jaundice	4	-	**0.006**

TSB: Total serum bilirubin

**Absolute change in TSB: Change in serum bilirubin level before and after phototherapy divided to phototherapy duration (mg/dl/hour).*

• Relative change in TSB at 4 and 24 hour:Percentage change in serum bilirubin level per hour after 4 and 24 hours of treatment.

devices with a 1:1 ratio of tubes could deliver up to 8 microwatts/cm²/nm, while a unit containing only special blue tubes which could deliver up to 12 microwatts/cm²/nm. LED phototherapy device (neoBLUE® LED Phototherapy system, Natus Medical Inc. San Carlos, CA USA) was utilized in the study group. Mean irradiance of blue LED unit at 20 cm distance was 35 microwatts/cm²/nm.

Total serum bilirubin (TSB) level was determined in capillary blood samples obtained by heelstick and the test was repeated at every 4 hours. Birth weight, gender, family history, ethiology of jaundice, initiation time of phototherapy, TSB level at the initiation of therapy and at 4, 24 hours and the last TSB level before cessation of phototherapy, rebound serum bilirubin level obtained 24 hours after termination of phototherapy and duration of phototherapy were recorded. 'Absolute' (change in serum bilirubin level per hour of photothetrapy treatment period) and 'relative' terms (percentage change in serum bilirubin level per hour after 4 and 24 hours of treatment) were calculated. Rebound jaundice was defined as the reincrease of serum bilirubin level to phototherapy treatment limit after 24 hours of phototherapy termination. Statistical analysis was performed by Student *t test* and X^2 test. Qualitative variables were compared with a X^2 test while an independent-samples *t test* was used for quantitative variables of patient characteristics. Statistical significance was defined as $p < 0.05$.

RESULTS

There were significant differences in the absolute change in serum bilirubin level per hour and relative change in serum bilirubin level at 24 hour between group I and group II ($p< 0.05$, for both). Rebound jaundice was observed in 4 of the neonates that received conventional phototherapy. Duration of phototherapy was shorter in the LED phototherapy group but this was not statistically significant (43.1 vs 32.1hrs) (Table 1).

There were no statistical difference in terms of birth weight, gestational age, gender, route of delivery, age at admission to the neonatal unit, serum bilirubin level at the initiation of therapy and at 4 and 24 hours and the last serum bilirubin level before the cessation of phototherapy (Table 1).

Blood extravasation (n:8, 23%), dehydration (n:9, 26%), hypothyroidism (n:2, 6%), focal infection (n:5, 14%), polycytemia (n:4, 11%) were among the demonstrable ethiologies of jaundice. Etiology could not be demonstrated in the rest of the patients. Family history, definable as siblings hospitalisation because of hyperbilirubinemia, was positive in 8 of 35 neonates (4 in each group).

DISCUSSION

In the present study, high intensity gallium nitride blue LED phototherapy was found to be more effective than conventional fluorescent phototherapy with respect to bilirubin photodegradation. LED phototherapy reduced TSB level in the first 24 hour of phototherapy significantly. Although, the duration of phototherapy in the patients who received LEDs seemed shorter, the difference between the groups was not statistically significant.

The incidence of significant rebound bilirubin was reported as 5.1% -13.3% in large number of neonates' series (8,9). According to AAP recommendations, neonates even in the high risk groups (direct Coombs' positive, borderline prematurity and those in whom phototherapy had been instituted <72 hours), should not be followed for the development of potentially dangerous post-phototherapy rebound hyperbilirubinemia (2). On the other hand, as conventional phototharepy devices instead of LEDs are still being used in developing countries, post-phototherapy bilirubin follow-up is usually used in practice. In our study, rebound hyperbilirubinemia was observed in 20% of conventional phototherapy group (n:4). Because the newborns in conventional group received much more time for phototherapy than the neonates in LED phototherapy group and their postnatal age's were older and they were slightly more mature at the time of rebound bilirubin determination. Lower serum bilirubin levels should be expected. On the contrary, their rebound hyperbilirubinemia rate was significantly higher. We didn't observe rebound hyperbilirubinemia in any of the patients that received LED phototherapy and accepted this observation as another clue for the efficacy of LED phototherapy.

Despite many potential benefits of LEDs recently reported (6,10), two clinical trials of LEDs did not report a higher efficacy when applied using relatively low irradi-

ance levels. These results suggest that effectiveness of phototherapy does not only depend on the color but also the irradiance of light (11,12). Chang et al (13) reported that LEDs showed a significant higher efficacy of bilirubin photodegradation than the conventional phototherapy both in vitro and in vivo. Contraversial reports concerning efficacy of LED phototherapy show that data related to LED phototherapy is still insufficient for its routine recommendation. Seidman et al compared the efficacy of LED phototherapy with an irradiance of >100 microwatts/cm²/nm to conventional phototherapy with 5-8 microwatts/cm²/nm irradiance. They found that the mean TSB concentrations at initiation and termination of phototherapy treatment did not differ between newborns receiving LED phototherapy and those receiving conventional phototherapy. They also reported that the duration of phototherapy and the rate of decrease in TSB concentration were not statistically different in the two groups. In contrast, LEDs with irradiance levels of 35 microwatts/cm²/nm reduced TSB level in the first 24 hour of phototherapy significantly in our study. Furthermore, Seidman et al have not reported the incidence of rebound hyperbilirubinemia. In our study, rebound hyperbilirubinemia was observed in none of the neonates that received LED phototherapy.

We conclude that the LED phototherapy was found to be more efficient than conventional phototherapy devices as they can provide rapid reduction in bilirubin photodegradation. The incidence of rebound hyperbilirubinemia with LED phototherapy seems to be less than conventional phototherapy and this may prevent unnecessary rebound bilirubin measurements in non-hemolytic jaundice.

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