Fiberoptic phototherapy versus conventional daylight phototherapy for hyperbilirubinemia of term newborns

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SUMMARY: Sarıcı SÜ, Alpay F, Dündaröz MR, Özcan O, Gökçay E. Fiberoptic phototherapy versus conventional daylight phototherapy for hyperbilirubinemia of term newborns. Turk J Pediatr 2001; 43: 280-285.

The efficacy and wavelengths of fiberoptic phototherapy and conventional daylight phototherapy were compared in a relatively larger series of term newborns with nonhemolytic and significant hyperbilirubinemia than reported in previous studies. One hundred and nine term newborns were randomly assigned to receive either fiberoptic phototherapy on a fiberoptic phototherapy pad or overhead conventional phototherapy consisting of five daylight fluorescent lamps. Although the average spectral irradiance measured during the study period was significantly greater in the fiberoptic phototherapy group (9.2 ± 1.2 $\mu W/cm^2/nm$ vs 7.1 ± 1.1 $\mu W/cm^2/mm$, $p < 0.05$), conventional phototherapy was significantly more effective in decreasing bilirubin levels: the duratilon of exposure to phototherapy was significantly shorter (49.4 ± 14.4 hours vs 61 ± 13.1 hours, $p < 0.05$), and overall bilirubin decline rate as mg/dl/h and percent/h was significantly greater in the conventional phototherapy group (0.15 ± 0.06 mg/dl/h vs 0.11 ± 0.05 mg/dl/h, and 0.81 ± 0.34 percent/h vs 0.60 ± 0.28 percent/h, $p < 0.05$). There were four failures of phototherapy in the fiberoptic phototherapy group whereas no phototherapy failure was observed in the conventional phototherapy group ($p < 0.05$). The emission spectrum of the daylight fluorescent lamp revealed a broad emission between the violet and red spectra with tiny narrow peak emission bands in 405 nm, 436 nm, 546 nm and 577 nm, while a broad emission through the blue and green wavelengths (mainly in the green spectrum) without any peak emissions was detected in the tungsten-halogen lamp of the fiberoptic phototherapy system. Conventional phototherapy with daylight fluorescent lamps shoud be preferred to fiberoptic phototherapy administered with fiberoptic phototherapy and in the treatment of term newborns with nonhemolytic hyperbilirubinemia.

Key words: conventional daylight phototherapy, fiberoptic phototherapy, hyperbilirubinemia, newborn.

Although conventional overhead phototherapy is still the treatment of choice for neonatal hyperbilirubinemia, it has several difficulties and disadvantages including respiratory obstruction from eye patches sliding over the newborn's nose, irritation of the eyes, and disturbances of the newborn's circadian rhythm[1,2]. The conventional phototherapy units consisting of special blue lamps can hinder clinical observations by masking skin color changes, such as cyanosis, and can cause nausea, giddiness and headache which discomfort the caregivers in the nursery[2,3].

These difficulties and disadvantages of conventional phototherapy units have prompted clinicians to search and use newer systems which are as efficacious as, but more practical and advantageous than, conventional phototherapy systems. In fiberoptic phototherapy, a recently developed technique of phototherapy, therapeutic light is delivered from a tungsten-halogen lamp through a fiberoptic cable and is emitted from the sides and ends of the fibers inside a plastic pad. Phototherapy is administered to either the newborn's front or back while the newborn lies on the pad. Using eye patches during fiberoptic

phototherapy is considered unnecessary as the newborn is unlikely to be in a position to look directly at the light source.

In two studies carried out with preterm babies, fiberoptic phototherapy was reported as efficacious as conventional phototherapy[4,5]. In two studies comparing the efficacy of fiberoptic phototherapy and conventional phototherapy in term newborns, serum bilirubin levels at the initiation of phototherapy were not high enough for starting phototherapy[6,7]. In another study fiberoptic phototherapy was compared with conventional phototherapy consisting of special blue light, but not daylight[8].

We performed this study to compare both the efficacy and wavelengths of fiberoptic phototherapy and conventional daylight phototherapy in a relatively larger series of term newborns with nonhemolytic and more significant hyperbilirubinemia than reported in previous studies.

Material and Methods

This study was performed at the Department of Pediatrics of Gülhane Military Medical Academy. It was approved by the local ethics committee, and written informed consent was obtained from parents before the randomization procedure. Healthy term newborns with birth weights of ≥ 2500 g and with nonhemolytic indirect hyperbilirubinemia normal hemoglobin, normal reticulocyte count, negative results of a direct antiglobulin test, and no evidence of blood group isoimmunization were enrolled into the study. Patients with direct hyperbilirubinemia, enclosed hemorrhage, infection, or any congenital malformations were excluded from the study. Gestational ages of the newborns were determined according to the maternal history and Ballard's scoring system[9]. Phototherapy was initiated at serum bilirubin levels of ≥ 15 mg/dl.

A total of 109 newborns were randomly assigned to receive either fiberoptic phototherapy or conventional phototherapy. Attending nurses sequentially allocated the newborns to one of the study groups, and they were not informed about the total serum bilirubin levels of the newborns at the study entry.

Newborns in the fiberoptic phototherapy group received fiberoptic phototherapy on a fiberoptic phototherapy pad (Walley II Phototherapy System, Fiberoptic Medical Products Inc, Allentown, PA, USA) which was in direct contact with the skin during phototherapy and provided an illumination area of 7.6 x 35.5 cm. Greatest care was taken to ensure that the active newborns were immediately placed back onto the phototherapy pad if they crawled off and moved out of the illumination area of the phototherapy pad.

Newborns in the conventional phototherapy group received conventional phototherapy below a standard phototherapy unit (Ohio Medical Products, Airco Inc, WIS, USA) consisting of five daylight fluorescent lamps (Sylvania Standard Daylight F 18 W/154, Sylvania Inc., MASS, USA) that was placed 30 cm above the newborns.

Phototherapy was administered to newborns of both groups in the prone position. They were diapered with disposable diapers folded to allow maximum skin exposure to phototherapy. The eyes of the newborns in the conventional phototherapy group were covered with eye patches during phototherapy, but these eye patches were not used in the fiberoptic phototherapy group. Phototherapy was administered continuously except during minor procedures such as feeding, physical examination and diapering. The newborns in both groups were fed with formula milk during phototherapy, and the daily fluid volume was adjusted according to clinical status and body weight loss associated with phototherapy. Newborns were closely monitored for possible side effects of phototherapy including changes in skin color, body temperature and weight, and gastrointestinal system functions.

Criterion for phototherapy failure was defined as continued increase in bilirubin concentration on two successive determinations beyond the pretreatment bilirubin level. The efficacy of phototherapy was compared by the following criteria: the duration of phototherapy (h) and the overall decerase in bilirubin concentration related to the total exposure time and expressed as a proportionate decrease per hour (mg/dl decline/h percent decline/h).

Direct bilirubin measurement, direct antiglobulin test, blood group typing, reticulocyte count, and complete blood count with differential were performed at entry into the study. Total serum bilirubin levels at entry into and during the study were measured in capillary blood samples every six to eight hours by direct spectrophotometry (Bilirubin Analyzer Bil Micro Meter Erma Inc. Kohsoku Denki Co, Ltd, Tokyo, Japan).

Phototherapy was terminated when total serum bilirubin levels had declined to < 12 mg/dl, but newborns were followed for at least 24 hours in case of rebound.

The spectral irradiance of light emitted during fiberoptic phototherapy was measured with Joey Dosimeter JD-101 (Fiberoptic Medical Products, Inc, Allentown, PA, USA) sensitive to wavelengths of 400-500 nm, and that of the conventional phototherapy system was measured with a standard radiometer (Minolta/ Air Shields Vickers Fluoro-Lite Meter 451) sensitive to wavelengths of 400-500 nm. By making serial measurements at the skin surface level of each newborn during the study, the average spectral irradiance was determined for each case. The emission spectra of the two different lamps used in the study groups were determined with monochromator (Garrel-Ash 50 cm, USA) at the Turkish Atomic Energy Authority. The data were statistically compared with the Student's t test.

Results

During the study period five newborns in the fiberoptic phototherapy group and four newborns in the conventional phototherapy group were excluded from the study due to various diagnoses such as hypothyroidism, infection and sepsis.

There were no significant differences between the fiberoptic phototherapy group and conventional phototherapy group with respect to factors that may influence the efficacy of phototherapy such as gestational age, birth weight, postnatal age, and bilirubin and hematocrit values at start of the treatment (Table I).

The posttreatment body weights also did not differ significantly between the fiberoptic phototherapy and conventional phototherapy groups (3420 ± 330 g and 3460 ± 290 g, respectively). During the study one newborn in the fiberoptic phototherapy group and one newborn in the conventional phototherapy group had transient erythema, and three newborns in each group had mild watery stool defecation not leading to dehydration. No other complications were observed during the sutdy.

There were four failures of phototherapy in the fiberoptic phototherapy group whereas no phototherapy failure was observed in the conventional phototherapy group ($p < 0.05$). These cases were transferred to our double phototherapy unit with high irradiance[10].

Phototherapy was effective in decreasing bilirubin levels in both groups, but the response was greater in the conventional phototherapy group; the duration of exposure to phototherapy was significantly shorter ($p < 0.05$), and overall bilirubin decline rate as mg/dl/h and percent/h was significantly greater in that group ($p < 0.05$; Table II).

Table I. Clinical and Laboratory Data of Study Groups

	Fiberoptic Phototherapy (n=50)	Conventional Daylight Phototherapy (n=50)	p
Male to female ratio	26/24	28/22	> 0.05
Gestational age (wk)	38.9 ± 0.7	39.2 ± 0.67	> 0.05
Birth weight (g)	3350 ± 410	3410 ± 300	> 0.05
Age phototherapy initiated (h)	106.0 ± 44.7	104.8 ± 41.3	> 0.05
Bilirubin (mg/dl)	17.8 ± 2.7	18.2 ± 2.8	> 0.05
Hematocrit (%)	54.1 ± 4.5	53.3 ± 4.7	> 0.05

Values are given as mean ± SD.

Table II. Responses of Groups to Phototherapy

	Fiberoptic Phototherapy (n=50)	Conventional Daylight Phototherapy (n=50)	p
Duration of phototherapy (h)	61 ± 13.1	49.4 ± 14.4	< 0.05
Overall bilirubin decline rate (mg/dl/h)	0.1 ± 0.05	0.15 ± 0.06	< 0.05
Overall bilirubin decline rate (percent/h)	0.6 ± 0.3	0.8 ± 0.3	< 0.05
Posttreatment bilirubin (mg/dl)	11.3 ± 0.5	10.9 ± 0.7	> 0.05

Values are given as mean ± SD.

After terminating the phototherapy, two newborns in the fiberoptic phototherapy group and three newborns in the conventional phototherapy group had rebound bilirubin values exceeding the pretreatment values, and these babies needed a second phototherapy exposure. The difference between groups was not statistically significant ($p > 0.05$).

The average spectral irradiance measured during the study period was significantly greater in the fiberoptic phototherapy group (9.2 ± 1.2 mW/cm²/nm vs 7.1 ± 1.1 μW/cm²/nm, $p < 0.05$). The emission spectra of the daylight and tungsten-halogen lamps of the conventional phototherapy unit and fiberoptic phototherapy system, respectively, are shown in Figure 1. In daylight lamps, a broad emission between the violet and red spectra with tiny narrow peak emission bands in 405 nm, 436 nm, 546 nm and 577 nm was detected. In the tungsten-halogen lamp on the other hand, a broad emission through the blue and green wavelengths (mainly in the green spectrum) without any peak emissions was detected (Fig. 1).

Discussion

The minimum average spectral irradiance level required for an effective phototherapy has been recommended to be between 4 to 12 μW/cm²/nm[11,12]. Considering this recommended range, mean spectral irradiances in both of our study groups were high enough to provide an effective phototherapy.

In the first studies comparing the efficacy of fiberoptic phototherapy and conventional phototherapy in term babies, fiberoptic phototherapy was reported as efficacious as conventional phototherapy[13,14]. In two other studies, fiberoptic phototherapy was used as an alternative to conventional home phototherapy, and equal efficacy was reported in the treatment of term newborns at home[15,16]. However, the bilirubin levels at the start of treatment in all these studies were between 11 to 14 mg/dl, and these low pretreatment levels might not accurately reflect the efficacy of phototherapy, and might render it difficult to make of correct comparison between various phototherapy methods[3]. Cases in our study

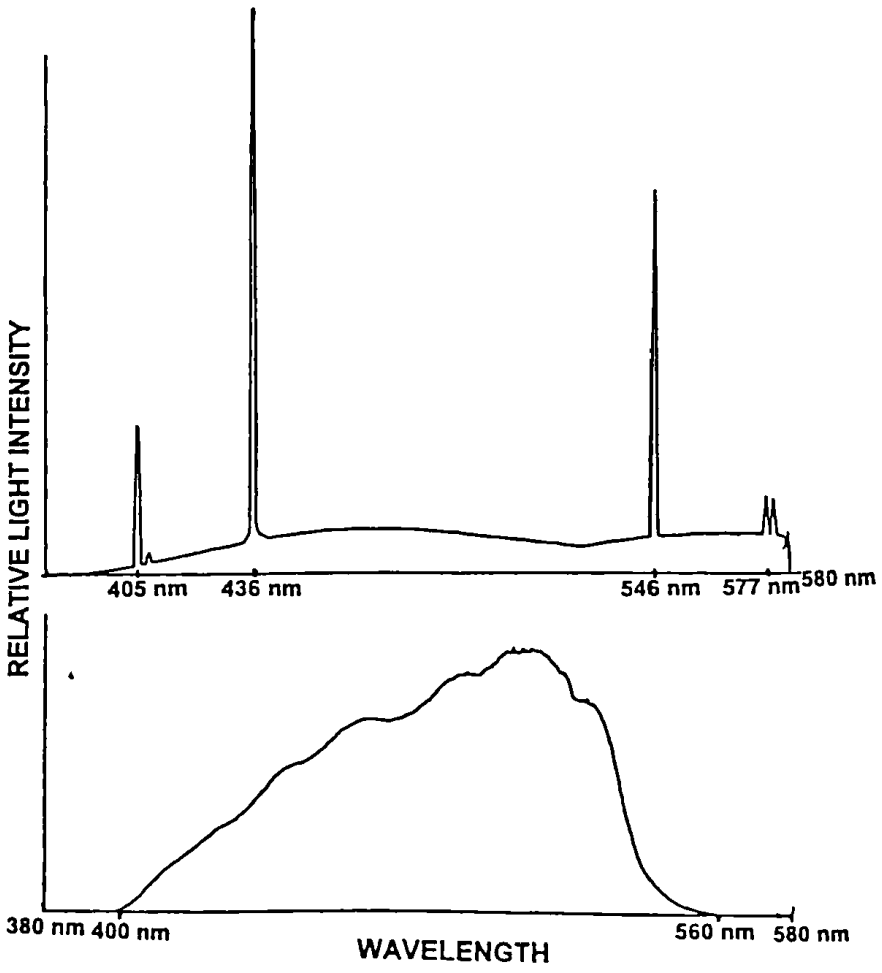

Fig. 1. Emission spectra of a daylight lamp (Sylvania Standard Daylight F 18 W/154) (top) and of a Tungsten-halogen lamp (fiberoptic phototherapy) (bottom).

groups had significant hyperbilirubinemia, and the mean bilirubin values at the initiation of treatment were significantly higher than those in all previous studies performed with fiberoptic phototherapy.

In preterm babies fiberoptic phototherapy was reported as efficacious as conventional phototherapy[4-6]. It was claimed that the efficacy of fiberoptic phototherapy in preterm babies was due to the skin properties of these babies which would permit increased light dosage absorption and better light penetration[6,17].

In two studies comparing the efficacy of in-hospital administration of fiberoptic phototherapy and conventional phototherapy in term babies, conventional phototherapy had significantly more efficacy[6,7]. Holtrop and associates[7] compared fiberoptic phototherapy and conventional phototherapy consisting of daylight and blue lamps, and they reported conventional phototherapy 2.5 times more effective than fiberoptic phototherapy after 18 h of treatment. They claimed that the increased efficacy was due to the significantly higher spectral irradiance of conventional phototherapy. Tan[6] compared fiberoptic phototherapy and conventional daylight phototherapy, and reported a mean decline rate of 0.49 pecent/h in 86.6 h in term babies with fiberoptic phototherapy. He stated that fiberoptic phototherapy in term babies, despite its higher irradiance, was not as efficacious as it was in preterm babies. Although the bilirubin decline with a mean rate of 0.60 percent/h in 61 h in our fiberoptic phototherapy group is seemingly more efficient than that see in Tan's study and in other studies, fiberoptic phototherapy was also less efficacious than conventional phototherapy in our study. The present study is the first study comparing fiberoptic phototherapy and conventional daylight phototherapy in term newborns with such significant hyperbilirubinemia.

Why fiberoptic phototherapy with higher irradiance was less efficacious than conventional phototherapy with less irradiance in our study must have been due to its feature of wavelength. The tungsten-halogen lamp of fiberoptilc phototherapy had an emission spectrum mainly in the green spectrum. The inability of green light to produce more bilirubin photoisomers than daylight, and the resultant decreased clinical efficacy of green light, have been shown previously[18,19]. We previously presented and compared the absorption spectra of fiberoptic phototherapy and conventional special bule light phototherapy in another study[8]. The absorption spectrum of daylight shown in the present study is the same as demonstrated earlier[20,21]. To our knowledge, ours is the first study comparing fiberoptic phototherapy and conventional daylight phototherapy by simultaneously demonstrating of their light sources.

Although fiberoptic phototherapy was less efficacious in this study, it had some practical advantages such as comfort of use, no need for eye patches, and easy accessibility and handling of newborns during phototherapy.

In phototherapy treatment of a relatively larger series of term newborns with more significant hyperbilirubinemia than reported in previous studies, conventional phototherapy with daylight fluorescent lamps demonstrated efficacy superior to fiberoptic phototherapy administered with phototherapy pad. Conventional phototherapy should be preferred to fiberoptic phototherapy in the treatment of term newborns with nonhemolytic hyperbilirubinemia.

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