A Comparison Between the Effect of Fluorescent Lamps and Quartz Halogen Incandescent Filament Lamps on the Treatment of Hyperbilirobinemia in Newborns with the Gestational Age of 35 Weeks or More

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Original Article

ABSTRACT

Background: Icter is the most prevalent disease in newborns. Although most of the newborns affiliated with this seem healthy in other aspects, there is always a fear for toxic complication of indirect hyperbilirobinemia in the central nervous system. Nowadays phototherapy is the method of decreasing (or avoidance of increase) of total serum bilirobin (TSB) and it is also used widely in neonatal health care centers according to the availably of equipment, but without any defined standard. In this study, two light sources, quarts halogen incandescent filament lamp (QHIFL) and fluorescent lamp (FL) are compared with each other to find out which method is more useful and efficient.

Methods: This study is a randomized controlled trial done on 25 newborns with gestational age of 35 weeks or more, with newborn's icter in the 1st week after birth, at Isfahan Behesti Hospital, February 2012 to March 2013. A group of these newborns was treated with FL and the other with QHIFL and they all were controlled and tested according to their level of TSB at the beginning of phototherapy, at 8th, 12th, and 24th h of treatment and at discharge. The data from the study was analyzed by IBM SPSS Statistics Version 21.

Results: According to the findings, the level of TSB before and 8 h after the intervention had no significant difference among the groups. However, at 16th and 24th h of treatment, the TSB level was lower in the FL group and this difference was meaningful ($P = 0.002$ and $P = 0.013$ respectively). Furthermore the duration of the treatment was significantly shorter in FL group meaningfully ($P = 0.047$).

Conclusions: According to the findings of this study, the technology used in QHIFL cannot show the capabilities of the FLs. However, more studies are needed to confirm the findings of this study are universal.

Keywords: Fluorescent lamp, hyperbilirobinemia, quarts halogen incandescent filament lamp

INTRODUCTION

Icter is the most prevalent disease in newborns and although most of the newborns affiliated with this seem healthy in other fields, there is always a fear for toxic complications of indirect hyperbilirobinemia on the central nervous system in these newborns. Icter happens when liver cannot pick enough amount bilirobin from the plasma, which may be due to high bilirobin Production (generally because of increased hemoglobin degradation) and also the limitation of bilirobin clearance (reduced uptake, reduced conjugation and less excretion) by the liver. On the other hand, the increase in enterohepatic circulation, which is proven undeniably in newborns than the adult, may play a role in icter development together with the previously mentioned reasons.[1]

If the level of indirect bilirobin Increases in the plasma to a level which denotes the probability of dangerous toxic complications, the basic intervention for it, i.e., phototherapy, must be carried out immediately. Nowadays phototherapy, although not defined as a standard, is not only method of decrease or avoidance of plasma indirect bilirobin, but also used widely in neonatal health care centers according to the devices available.[2]

Considering the effect mechanism of phototherapy in the treatment of, we should note that light, affecting the unconjugated bilirobin in the skin, subcutaneous and capillary reduces the level of indirect plasma bilirobin in three separate processes:

- One of these important processes is the creation of numeral photo isomers out of indirect bilirobin in a way that the indirect bilirobin, while normally exposing the 15Z, 4Z spatial formation, produces other spatial formations (4E, 15Z; 4Z, 15E; 4E, 15E) by the absorption of light especially in the range of 460 ± 10 nm. These formations of photo isomers, known as E isomers, are bile soluble and enter the digestive system without the need for conjugation
- Lumirubin, a structural isomer formed by the effect of light on unconjugated bilirobin, is bile and urine soluble and it can be excretion without the need for conjugation
- A new photo catabolism method is recently discovered for the unconjugated bilirobin which is followed by the products of unconjugated bilirobin oxidation (biliverdin, dipyrroles and monopyrroles) and is thought to be excreted in the liver or kidneys without any need for conjugation.

Among all these routes, geometric photo isomerization has the most important role (80%) in reduction of the unconjugated bilirobin level through phototherapy.[3]

Considering the light spectral which can facilitate bilirobin photo catabolism, we can say that bilirobin widely absorbs the electromagnetic wavelengths in the range of 340 nm to 540 nm, which is identical to the range of spectral visible purple (less than 455 nm) to green (more than 492 nm); however, the absorption of photons is maximal in the range of blue color (420 nm to 480 nm) and specially for the wavelength of 458 nm (special blue) (for non-albumin bound bilirobin this wavelength is less [440 nm/460 nm] than the albumin bound bilirubin). This criterion for the light source phototherapy is measured by spectrophotometry.[4]

The efficacy of phototherapy in the treatment of hyperbilirobinemia also depends on another characteristic than the quality of spectrum (wavelength), named Irradiance. Irradiance in fact manages the packs of photons and as more photons are absorbed by the unit of surface, more energy is provided for photo catabolism of bilirobin. This effective factor in the dose of phototherapy is measured by a radiometer and the minimum irradiance acceptable for the phototherapy is about 6-12 $\mu W/cm^2/nm$ and if a light source can produce irradiance higher than 25 $\mu W/cm^2/nm$ in the surface unit of skin, it would be referred to as intensive phototherapy. We must also pay attention to the point that irradiance, other than the technical characteristics of the light from the source, relies on the distance of the light source from the skin.[5]

Light emitting sources which are used for phototherapy are categorized in the four following classifications based on the technology used in them and aim to produce a beam of light which has the highest care efficacy and the lowest risk of complications.

- Fluorescent lamps (FLs); FLs which have been used widely in the treatment of newborns icter during the last 40 years are categorized in two groups of long tubes and folded (compact) tubes and their most important advantage is that these devices are cheap; however, during

their application it should be noted that theses lamps lose irradiance through time and they have a limited life span. Moreover, their irradiance alters according to the beam's color (blue, white, or green)

- Halogen light emission sources or quarts halogen incandescent filament lamps (QHIFL) or simply halogen bulbs; halogen lamps, which are designed based on emission of light from an Incandescent string, provide a wide light output (white) based on the wavelength which covers the yellow to red bands with a high irradiance; however, due to the high level of heat emission we cannot place them close to the skin. These light sources, as opposed to FLs, do not pose the limitation of losing irradiance through time and considering the white light emitted, their usage imposes less tension in the work atmosphere
- Metal halide gas discharge lamps; this group of light sources, which are also referred to as exhaustive lamps, are designed on the basis of electric discharge in a gas environment, like FLs and they produce a blue-white light but with high irradiance
- Light emitting diodes (LED); blue LED light sources are based on electric stimulation of a mineral (gallium nitride) and due to pure emission in the range of blue light, they produce less heat. Therefore, we can place these light sources very close to the skin, which in turn maximizes the absorbed irradiance at the surface of the skin.

In fiber optic phototherapy systems, the light emission source can be one of the following sources, whereas the light is transferred to a contact pad on the newborn's skin surface through optical fibers.[6]

Considering the point that the technological characteristics implemented in these devices are comprehensively analyzed *in vitro*, it can be concluded that studies done on the relation of their performance *in vivo* compared with each other are very limited, hence, considering the development and evolution of these devices, making such comparisons through clinical trials seems increasingly necessary.[7]

METHODS

This study is a randomized controlled trial done at Shahid Beheshti Hospital, Isfahan, Iran from February 2012 to March 2013. This study is approved by Human Ethical Committee of Isfahan Medical University under reference number 391291.

Sample size calculations

The following formula was used to calculate the sample size:

$N = [(Z_1 - \alpha/2) + (Z_1 - \beta)] \times (S_1^2 + S_2^2)/d^2$

Confidence interval

$Z_1 - \alpha/2$ and $\alpha = 0.05 - 1.96$

Statistical power

$Z_1 - \beta$ and $\beta = 0.2 - 0.84$

The standard deviation (SD) in QHIFL group will be equal to 0.6 ($S_1 = 0.6$).

The SD in FL group will be equal to 0.5 ($S_2 = 0.5$).

$d = 0.37$

$n = 35$.

The study population included newborns with gestational age of 35 weeks or more who were hospitalized in the neonatal section during the 1st week after their birth due to icter. Inclusion criteria included: Being healthy (no hypoxia, hypotonic, infectious, dehydration, or temperature instability disorder demonstrations observed) during medical examination, no Foe to-maternal incompatibility of Rhesus (Rh) type, total serum bilirobin (TSB) level equal or higher than 11.7 mg/dL in week 35-37 of gestation, TSB level of 12.8 mg/dL at the gestational age of 38 weeks or more and last but not least, parents consent for the newborn to be included in the study. Exclusion criteria included: Conjugated plasma bilirobin at the level of 1.3 mg/dL or more, TSB level equal or more than 15.4 mg/dL, severe Hemolytic disease (anemia with Hb < 14 g/dL and/or hyperbilirobinemia before 48 h from birth), and phototherapy before the onset of the study.[8,9] These newborns were entered in the study by a pediatric resident after careful examination and reviewing their conditions.

In order to randomize the trial, newborns with even initial document numbers were put in QHIFL and those with odd numbers were placed in FL group and sampling continued until the desired number of samples entered both groups.

FL group newborns were treated with 4 FLs (TL/20w/52, Philips Holland) after they were put on the open crib.[10]

In QHIFL group, the newborns were treated with halogen system phototherapy (Bilispot,

Fanem Sao Paulo-Brasil) after they were placed on the open crib. The light source was placed 45-50 cm from the newborn's skin in a way to illuminate a circle with the diameter of 18 cm.[11]

Irradiance level in both groups was measured by a radiometer (Radiometer 2620, Fanem Sao Paulo-Brazil) at the beginning of the treatment and each 24 h after the start; the minimum acceptable irradiance was equal to 15 $\mu W/cm^2/nm$. This measurement was done on the surface of face, xiphoid and the knees.[12]

TSB assessment was done by capillary sampling, based on spectrophotometry on an 8 h basis for the first 24 h and after that each 12 h. Phototherapy was discontinued if two successive TSB was categorized under the level of "conventional phototherapy" based on nomogram in American Academy of Pediatrics (AAP) guidelines for phototherapy in hospitalized infants of 35 or more weeks' gestation.[10]

Findings were recorded in a list designed for this purpose and they were analyzed by SPSS 20 software after entrance into computer database.

RESULTS

A total of 25 newborns were placed in each of the groups of FL and QHIFL. Demographic information of the study patients are given in Table 1. According to *t*-test, the average age at the time of hospitalization and average gestational age, direct and total bilirobin level showed no meaningful difference ($P > 0.05$). Moreover, according to Chi-squared test and fisher's exact tests, gender distribution, blood type and Rh also showed no meaningful difference ($P > 0.05$).

As has shown in Table 2, the mean and SD of total bilirobin level at the time of hospitalization (TSB at 0 h), 8 h after, 16 h after and 24 h after phototherapy and also at the time of discharge from hospital are given. *T*-test administration on the mentioned findings showed that the level of total bilirobin before and 8 h after the intervention showed no meaningful difference in both groups. However, the same level at 16 and 24 h after the phototherapy was lower meaningfully in FL group. No meaningful difference was found at the time of discharge from hospital.

Repeated variance analysis revealed that the change in total bilirobin during the intervention showed a meaningful difference ($P < 0.001$). In Figure 1, total bilirobin level change during the intervention is given.

The average hospitalization duration in FL group was $2 \pm 0/58$ days and the same was $2/33 \pm 0/57$ days in the QHIFL group, which according to *t*-test, the mean of hospitalization duration in FL group was lower significantly ($P = 0.047$). In Figure 2, the distribution of hospitalization duration is given for both groups.

DISCUSSION

In a study done by Sarin *et al*. for the comparison of phototherapy through special blue standard-length tube lights (STL) and special blue compact fluorescent lamp (CFL), icter affiliated newborns with gestational ages less than

Table 1: Demographic and basic variables distribution in both groups

Variable	Group	Level	FL	QHIFL	*P* value
Age	Day	-	3.32±1.11	3.48±1.12	0.62
Sex	Female	-	13 (52)	16 (66/7)	0.3
	Male	-	12 (48)	8 (33/3)	
Gestational age	Week	-	37.4±1.61	37.33±1.59	0.07
Blood group	A	-	5 (20)	5 (20/8)	0.92
	B	-	5 (20)	4 (16/7)	
	AB	-	4 (16)	6 (25)	
	O	-	11 (44)	9 (37/5)	
Rh	Positive	-	21 (84)	19 (79/2)	0.73
	Negative	-	4 (16)	5 (20/8)	
TSB	-	mg/dL	14.05±2.9	12.83±2.56	0.12
Direct bilirobin	-	mg/dL	0.44±0.096	0.43±0.096	0.6

FL=Fluorescent lamp, QHIFL=Quarts halogen incandescent filament lamps, TSB=Total serum bilirobin

Table 2: The mean and the standard deviation of plasma TSB during the treatment (mg/dL)

	FL	QHIFL	*P* value
Before intervention	78/2±25/14	66/2±28/13	0.11
At 8th h	81/2±52/11	92/2±08/12	0.26
At 16th h	32/2±5/9	64/3±35/11	0.002
At 24th h	93/1±07/8	02/4±47/10	0.013
Time of discharge	61/1±55/7	57/1±71/7	0.86

FL=Fluorescent lamp, QHIFL=Quarts halogen incandescent filament lamps, TSB=Total serum bilirubin

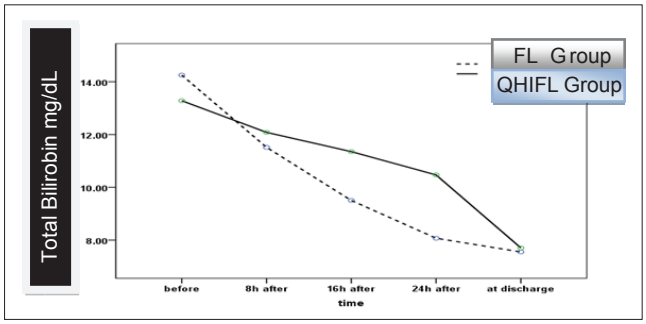

Figure 1: The change trend in the level of total serum bilirobin during the intervention in both groups

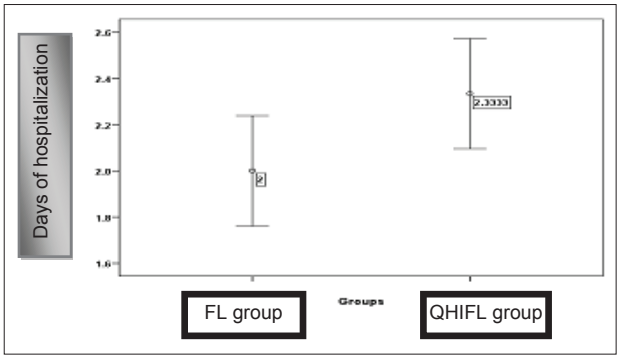

Figure 2: The mean and the confidence interval for the duration of hospitalization in both groups

34 weeks who were healthy from other aspects and not affiliated with Rh iso-immunized and needed phototherapy according to AAP guidelines, were included in the study. 50 newborns were included in each group (STL and CFL) and each 12 h their TSB level was assessed and if two successive assessments showed the level of TSB under the minimum level for phototherapy, this intervention would be discontinued. Findings of this study showed no meaningful difference between the two groups according to duration of treatment and the need for blood exchange.[10]

In a study done by Kumar *et al*., newborns with gestational age of 35 weeks or more who faced icter during their 1st week after birth were treated by phototherapy according to AAP guidelines. They were placed in two groups of compact fluorescent tube (CFT) and LED. There were 142 newborns in LED and 130 newborns in CFT group. This study showed no significant difference according to treatment duration, unsuccessful phototherapy attempt, need for blood exchange and phototherapy complications.[8]

In a study by Romagnoli *et al*., done on newborns with gestational age of equal or less than 30 weeks affiliated with icter, who had plasma total bilirobin level of equal to 6 mg/dL, were treated with phototherapy in two groups through units of fluorescent and fiber optic systems with halogen light emitting sources (Wallaby). The newborn's TSB level was assessed every 12 h while considering the phototherapy failure at the level of TSB = 14 mg/dL. There were 35 newborns in each group and this study revealed that the newborns treated with Wallaby system meaningfully needed less duration of phototherapy intervention; Moreover, the need for blood exchange was also lower in this group rather than the newborns in fluorescent group.[13]

In a study by Seidman *et al*., newborns with gestational age of equal or more than 35 weeks affiliated with icter, who were completely healthy in other aspects, were treated in two groups by halogen light systems (n = 57) and LED systems (n-47) and their TSB level was assessed each 12 h. No meaningful difference was shown between the two groups according to their need for blood exchange.[9]

In a study by Martins, newborns weighing 1000 g or more with icter were placed in two groups of 44 newborns each and they were treated with halogen and LED phototherapy. TSB samples were analyzed each 8 h. The mean TSB in LED group at the beginning of the treatment was equal to 10.1 ± 2.4 mg/dL, while the same was 10.9 ± 2.0 mg/dL in the halogen group. This study showed that the speed of TSB decrease in LED group was slower than the one in halogen group, hence making the duration of treatment less in halogen group.[11]

Considering the point that the general aim of this study is to compare the effect of light source

in QHIFL and FLs on the treatment of jaundice for healthy newborns with gestational age of 35 weeks or more and considering the point that the demographic and basic variables showed no significant difference according to age at the time of hospitalization, gender, blood type, Rh, age of pregnancy and the first TSB level, therefore these interfering variables are neutralized and the resulting findings are most probably related to the effect of the treatment on the newborns TSB level.

Although in Romagnoli study the speed of reduction of TBS level in the halogen group was meaningfully faster than fluorescent group and as a result the duration of treatment was meaningfully shorter in halogen group and this difference is against the findings of the current study, we should note that in Romagnoli, the QHIFL light source was directly connected with the skin of the newborn through optical fibers and a pad, whereas in the current study the QHIFL light source is placed at the distance of 45-50 cm from the skin to avoid hyperthermia.

Owing to the limited number of studies in this field, it is advised to use the QHIFL sources for phototherapy with the hardware basis of optical fiber systems.

CONCLUSIONS

According to the findings of this study, the technology used in QHIFL cannot show the capabilities of the FLs. However, more studies are needed to confirm the findings of this study are universal.

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