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Original Research Article

Effectiveness of light emitting diode versus conventional phototherapy in neonatal hyperbilirubinemia: a hospital based observational study

Radheshyam Purkait, Manik Mondal*

Department of Pediatrics, Nil Ratan Sircar Medical College and Hospital, Kolkata, West Bengal, India

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***Correspondence:**
Dr. Manik Mondal,
E-mail: msaktidas@gmail.com

ABSTRACT

Background: The most commonly used light sources in the conventional phototherapy units are compact fluorescent lamp (CFL), halogen spotlights and fiberoptic blankets. Recently light emitting diodes (LED) has emerged as better light source for phototherapy and almost replacing all the available conventional light sources. Comparative studies on the efficacy of LED versus conventional phototherapy are limited from India. That is why; this study was undertaken.
Methods: 48 neonates of ≥35 weeks gestational age with hyperbilirubinemia were participated in this study. Among them, 24 neonates received conventional phototherapy and rest of them received LED phototherapy. The rate of fall of bilirubin levels at 6 hours and at completion along with total duration of phototherapy in both groups was measured. Results analysed by standard statistical methods.
Results: LED phototherapy units showed higher rate of fall in bilirubin at six hrs (LED group: 0.38±0.05 mg/dl/hr versus conventional group: 0.30±0.04 mg/dl/hr, $p<0.05$) and after completion of therapy (LED group: 0.32±0.03 mg/dl/hr versus conventional group: 0.26±0.03 mg/dl/hr, $p<0.05$) compared to conventional group. Significant difference was documented in total duration of phototherapy in LED group (30.8±1.8 hours) when compared to conventional group (34.6±0.7 hours). None of the neonate showed phototherapy failure. Side effects were minimal and comparable in both the groups.
Conclusions: The LED phototherapy units are more efficacious in terms of higher rate of fall of bilirubin levels and lesser duration of phototherapy compared to conventional phototherapy units.

Keywords: Conventional phototherapy, Light emitting diode, Neonatal hyperbilirubinemia, Phototherapy

INTRODUCTION

In India, among hospital born neonate, 3% develop total serum bilirubin (TSB) levels more than 15 mg/dL.[1] Phototherapy being non-invasive, cheap, safe and with fewer side effects have become the treatment of choice for the management of neonatal hyperbilirubinemia worldwide. It is most effective in lowering serum bilirubin when wavelength of the light output is in blue to green spectrum (420 to 490 nm).[2] However, there is no standard method of delivering phototherapy. The efficacy of phototherapy is largely depends on the colour (wavelength) and intensity (irradiance) of the light emitted during phototherapy, the exposed body surface area and the duration of exposure. According to the current guidelines of American Academy of Pediatrics (AAP), intensive phototherapy is defined as the use of blue light (430-490 nm wavelengths) delivered at 30 microwatts/cm²/nm or higher to the greatest body surface area as possible.[3]

The most commonly used light sources in the conventional phototherapy units are compact fluorescent lamp (CFL), halogen spotlights and fiberoptic blankets (for contact use). However; these devices are less effective and each of these devices has many disadvantages that include high heat production and only limited surface area exposure.[4] Recently, high intensity gallium nitride derived light emitting diodes (LED) have been developed which provide higher irradiance, narrow spectrum wavelength, minimal heat production and extended life span compared to all currently available conventional phototherapy units (durable light sources with an average life of 20,000 hours compared to 2000 hrs in CFL). These LED units can be placed very close to the neonate without any significant adverse effects.[5-8]

After the development of LED, a lot of research was conducted around the world comparing the efficacy of LED phototherapy versus conventional phototherapy in the management of neonatal jaundice, but published studies from India is limited.[9,10] Hence, the study was conducted comparing the efficacy of LED device with conventional phototherapy device by measuring serum bilirubin levels in neonates with hyperbilirubinemia.

METHODS

Two prospective studies were carried out in the Neonatal Intensive Care Unit (NICU) at the institute on neonatal jaundice due to G6PD deficiency. First prospective study was done from April 2012 to March 2013 and the second one was conducted from April 2018 to March 2019. For both the study, necessary approval from the ethics committee of our institute was taken. In the present study, we have collected all the data retrospectively and analysed. Here, all inborn babies (babies who were born in the present institute) of ≥35 weeks of gestation who had developed pathological jaundice were included due to G6PD deficiency and subsequently treated with phototherapy. Demographic and baseline characteristics of study population including gender, birth weight in grams, gestation in weeks and age in hours were recorded in each neonate before starting phototherapy.

Inclusion criteria

- Newborn babies up to 7th day of life, born after 35 weeks of gestation who required phototherapy for hyperbilirubinemia,
- A level of serum bilirubin (SB) at which phototherapy was started was based on American Academy of Pediatrics (AAP) guidelines.
- Phototherapy was stopped when serum total bilirubin levels were < 12 mg/dl as per AAP guidelines and institutional protocol.

Exclusion criteria

- Babies requiring exchange transfusion or intensive phototherapy,
- Conjugated hyperbilirubinemia (Conjugated SB > 2 mg/dl),
- Rh hemolytic disease,
- Culture positive or proven sepsis,
- DCT positive or any evidence of hemolysis,
- Perinatal asphyxia (Apgar score <4 at 1 min, <7 at 5 min),
- RDS,
- Major congenital anomalies,
- Age > 7 days,
- Gestation < 35 weeks,
- Infant of diabetic mother,
- Congenital hypothyroidism,
- Already received phototherapy before admission,
- Refusal to give written consent for study Enrolment.

In the first study (conventional group): 24 neonates had been treated by conventional phototherapy unit that made up with a combination of alternating four blue and 2 white tube lights (20 W each) that provided irradiance of 8-12 $\mu W/cm^2/nm$ with a wavelength of 425-475 nm (Neocare Equipments, Mumbai, India). Whereas, in the second study (LED group): 24 neonates had been treated by Phoenix LED Phototherapy unit which provided maximum irradiance of 50 $\mu W/cm^2/nm$ with a wavelength of 450 to 460 nm (Phoenix Medical Systems Pvt Ltd, Tamil Nadu, India). New lamps were installed in all the units at the beginning of the study. Irradiance of the phototherapy unit was measured by Ohmeda's Biliblanket Meter II.

In both the groups, each enrolled neonate received phototherapy using a single overhead phototherapy unit. A uniform distance of 40 cm was maintained between the baby and the lamp surface in each case. All the babies who had been exposed to phototherapy were completely naked and appropriate measure was taken to protect the eyes and diaper region. Weight of the neonate was recorded daily and temperature monitoring was done every sixth hourly. Hypothermia was considered if the recorded temperature fell below 36.5 degree Celsius. Hydration status was assessed based on physical examination and daily weight monitoring. Dehydration was defined if there was documented weight loss greater than 5% in a day. Any side effects including skin darkening, rashes, and diarrhoea were noted. Tanning of skin during phototherapy was considered as evidence of skin darkening.

Irradiance of the respective phototherapy unit was measured at the start of study and then every 6 months until completion of the study in both the study groups. Total serum bilirubin (TSB) was initially measured at 6 hours of phototherapy, then it was measured every 12^{th} hourly until intervention was completed. Repeat examination of TSB levels was done 24 hours after cessation of phototherapy to assess rebound rise.

Primary outcome was measured in the term of the rate of fall of serum bilirubin and duration of phototherapy required. The rate of fall of bilirubin was calculated at 6 hours and after completion of total duration of intervention. The total duration of phototherapy was calculated by subtracting age at start of phototherapy from age at end of phototherapy in hours. The brief periods of discontinuation of phototherapy for the purpose of feeding or changing nappy were not excluded while calculating total duration.

Secondary outcome consisted of hypothermia, dehydration, appearance of rash and failure of phototherapy. Failure of phototherapy was defined as total serum bilirubin rising to more than 20 mg/dl during phototherapy which required either use of double surface phototherapy or exchange transfusion. Windostat Version 9.2 software was used for data entry and analysis. Continuous data with normal distribution was analysed by Student t-test and categorical data was analysed by chi-square or Fisher exact test. A P value of <0.05 was considered as statistically significant.

RESULTS

Forty-eight near term and term neonate with indirect hyperbilirubinemia due to G6PD deficiency were included in the present study. All neonates received phototherapy. Of these, 24 infants received conventional phototherapy (Conventional group), while 24 infants received LED phototherapy (LED group). Demographic and baseline characteristics of the two study groups showed no significant difference (Table 1).

Table 1: Demographic and baseline characteristics in both groups.

Characteristics	Conventional group (n = 24)	LED group (n = 24)	p- value
Male/female	14/10	15/9	-
Birth wt (gm)	2800.83±278.93	2750.83±280.72	0.763
Gestation in wks	37.50±1.87	36.67±1.63	0.430
Age in hours	98.3±20.7	97.5±19.7	0.944
Wt at admission (gm)	2602.50±280.46	2573.33±293.17	0.8637

Table 2: Comparison of results and analysis in both groups.

Characteristics	Conventional group (n = 24)	Led group (n = 24)	p value
TSB at start (mg/dl)	19.33±1.73	19.77±1.70	0.664
TSB at 6 hr (mg/dl)	17.51±1.51	17.52±1.41	0.985
TSB at discharge (mg/dl)	10.30±0.73	10.10±0.79	0.613
Rebound TSB (mg/dl)	11.24±0.66	11.35±0.74	0.790
Rate of fall of TSB at 6 hrs of PT ((mg/dl))	0.30±0.04	0.38±0.05	0.019
Rate of fall of TSB at the end of PT (mg/dl)	0.26±0.03	0.316±0.03	0.012
Phototherapy duration (hours)	34.6±0.7	30.8±1.8	0.001

Mean serum bilirubin level of 24 neonates in conventional group was 9.33±1.73 mg/dl at start, 17.51±1.51 mg/dl at 6 hour and 10.30±0.73 mg/dl at the time of discharge. Rate of fall of serum bilirubin during first six hrs was 0.30±0.04 mg/dl/hr and overall rate of fall was 0.28±0.05 mg/dl/hr. Total phototherapy duration was 34.6±0.7 hour. Mean serum bilirubin level of 24 neonates in LED group was 19.87±1.70 mg/dl at start, 17.52±1.41 after 6 hrs and 10.07±0.79 mg/dl at the time of discharge. Rate of fall of serum bilirubin in LED group during first six hours was 0.38±0.05 mg/dl/hr and overall rate of fall was 0.32±0.03 mg/dl/hr. Total phototherapy duration in LED group was 30.8±1.8 hour. There was no significant difference in initial serum bilirubin levels, at 6 hour of phototherapy and at the time of discharge in both the study groups. However, rate of fall of serum bilirubin after first six hours was higher in LED group (0.38mg/dl/hr) than conventional group (0.30mg/dl/hr) and was statistically significant (p = 0.019). Similarly overall rate of fall of serum bilirubin at the time of discharge was higher in LED group (0.32 mg/dl/hr) than conventional group (0.26 mg/dl/hr) and was statistically significant (p = 0.012). Total phototherapy duration in LED group is lower (30.8 hour) as compared to conventional group (34.6 hour) and was statistically significant (p = 0.001). The rebound rise of SB after 24 hours of stoppage of phototherapy is 11.24 mg/dL in conventional group and 11.35 mg/dL in LED group, which is statistically insignificant (p=0.790) (Table 2).

Side effects were rare and comparable in both groups. In LED groups two babies had hypothermia and rash

noticed in two babies. In conventional group two babies had hyperthermia, one baby had mild dehydration and rash was noticed in three babies. None of the babies in our study had failure of phototherapy. After discharge, none of the babies required phototherapy for rebound rise in serum bilirubin level. Otoacoustic Emission (OAE) tests were normal in all babies.

DISCUSSION

Neonatal jaundice is a benign condition, but causes irreversible brain damage, which leads to bilirubin encephalopathy especially in preterm babies if high level of unconjugated bilirubin persists in the blood for longer duration. The management of neonatal hyperbilirubinemia have been changing over years. Phototherapy being non-invasive and safe method has been used since decades in decreasing neonatal hyperbilirubinemia. However, there is no standard recommended phototherapy device with highest efficacy and little side effects. Most commonly used light sources that are used now are conventional Compact Fluorescent Light (CFL) units followed by newly developed Light Emitting Diode (LED) phototherapy units.[11,12]

The study compared efficacy of conventional and LED light in reducing serum bilirubin to safe level. It showed that with LED phototherapy rate of fall of serum bilirubin is more compared to conventional phototherapy i.e. 0.38 mg/dl/hr versus 0.30 mg/dl/hr in first 6 hour and 0.32 mg/dl/hr versus 0.26 mg/dl/hr towards the end of the treatment. Similarly, total duration of phototherapy to achieve safe bilirubin level is more with conventional units (34.6 hours) as compared with LED units (30.8 hours). This observation matched with the studies done by Swain N et al, Reddy TR et al. and Gutta S et al. where they used phototherapy units with irradiances similar to our study.[11-13] However, on the contrary, Takcı S et al, Mohammadizadeh M et al. and Kumar P et al. have concluded that there is no significant difference in rate of decrease in serum bilirubin levels between LED and conventional phototherapy group, since they all had compared between different intensive phototherapy units with matched irradiances as per criteria of American Academy of Pediatrics.[14-16] Side effects like hypothermia, rash, dehydration, significant rebound rise in SB after stoppage of phototherapy and failure of phototherapy were rare and comparable in both groups like previous studies done by Reddy TR et al and Kumar et al.[12,16]

The present study has few limitations. Comparing between intensive LED and intensive conventional phototherapy as per the current guidelines of American Academy of Pediatrics is essential in the setup.

CONCLUSION

The LED phototherapy units are more efficacious in terms of faster rate of fall of bilirubin levels and lesser duration of phototherapy compared to conventional phototherapy units. Side effects were minimal and comparable with both the groups.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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