Comparison of Phototherapy with light-editing diodes (LED) and Conventional Phototherapy (fluorescent lamps) in Reducing Jaundice in Term and Preterm Newborns

Majid Hamidi (1)
Fatemeh Aliakbari (2)

(1) Assistant Professor, Department of Pediatrics, Shahrekord University of Medical Sciences, Shahrekord, Iran
(2) Assistant Professor, Department of Medical-surgical Nursing, Shahrekord University of Medical Sciences, Shahrekord, Iran

Corresponding author:
Fatemeh Aliakbari
Department of Nursing, Shahrekord University of Medical Sciences,
Rahmatiyeh, Shahrekord, Iran
Email: aliakbarifa@gmail.com

Received: December 25, 2017; Accepted: December 30, 2017; Published: March 1, 2018. Citation: Majid Hamidi, Fatemeh Aliakbari. Comparison of Phototherapy with light-editing diodes (LED) and Conventional Phototherapy (fluorescent lamps) in Reducing Jaundice in Term and Preterm Newborns. World Family Medicine. 2018; 16(3):123-128. DOI: 10.5742/MEWFM.2018.93319

Abstract

Background: Jaundice is a common problem in neonates and the most common cause of hospitalization in Iran. The aim of this study was to compare safety and efficacy of LED and conventional phototherapy to treat hyperbilirubinemia.

Materials and methods: A randomized clinical trial was conducted on 130 term and near term infants over 35 weeks, hospitalized in a neonatal care unit and who needed conventional phototherapy. Samples were randomly divided into two groups: LED and conventional phototherapy. Outcomes included the rate of fall of total serum bilirubin (TSB, mg/dL/hour) and measured duration of phototherapy. Data were analyzed by SPSS software with descriptive statistics, t-test, and analysis of variance (ANOVA).

Results: TSB level was not different in the two groups before the intervention (P=0.187). LED phototherapy was more effective in reduction of the level of TSB at 6, 12, and 24 hours. (P<0/05). Of the reduction from 12 hours to 24 hours, the highest and the lowest decrease in TSB occurred between 6 and 12 hours. Treatment duration was 50.18±6.7 in LED and 65±13.7 hours in the conventional group (P<0.05).

Conclusion: LED phototherapy is as effective as conventional phototherapy and reduces the treatment time and a further reduction of the relative change in TSB. The LED phototherapy has less frequent side effects and lower costs.

Key words: Phototherapy, Hyperbilirubinemia, TSB, LED

Introduction

Jaundice is a common condition in newborns. In total 60% of term babies and 80% of preterm babies are affected in the first week after birth (1, 2). Indirect bilirubin levels exceed 20 mg/dl and increase the risk of neurologic system disorder and bilirubin bonding with basal nuclei and brainstem nuclei (1).

Disregarding the cause, treatment of hyperbilirubinemia is focused on prevention of neurotoxicity (3). Phototherapy is still a major treatment for preserving serum total bilirubin levels below pathogenic level (4). Yet in case of failure, exchange transfusion is the last option (3).

Considering abundant complications of exchange transfusion in newborns such as hypoglycemia, hypocalcaemia and sepsis risk, thrombocytopenia, and even death, phototherapy is the first choice in hyperbilirubinemia treatment in newborns (5). Phototherapy is the commonest interventional procedure for severe hyperbilirubinemia prevention and treatment. This procedure has been greatly effective in reducing hyperbilirubinemia complications and transfusion in millions of newborns all over the world (6). Bilirubin absorbs blue light with a wavelength of 420-470 manometers better. Bilirubin in skin absorbs light energy and causes a large number of photochemical reactions (5).

The light source used in conventional phototherapy is made up of four lamps placed 40 centimeters away from the body. The effect depends on factors such as bilirubin levels, type of phototherapy used, exposure area, use of aluminum foil and white cloth for better reflection, and use of fiber optic blankets (7,8). In a study conducted by Maisels et al in 2007, a randomized controlled trial, the study mentions a number of advantages for the light-editing diodes (LED) technique including: lower energy consumption, longer endurance time of the lamps, infrared- free and ultraviolet- free radiation, and higher cost efficiency (9). To the best of our knowledge on LED phototherapy, more randomized controlled trials on the issue seem necessary (10) since neonatal jaundice is a common cause for newborn hospitalization in our country (8) and a large number of beds host these babies in our country every year. Also, since various techniques are being applied in different parts of the world as an attempt to treat the condition through reducing phototherapy complications (11), lowering hospitalization period(12), and decreasing bilirubin levels in a shorter time(13), this study was conducted to investigate the efficiency of LED and conventional phototherapy regarding hospitalization period, bilirubin reduction, and easing the complications.

Materials and methods

This randomized controlled trial was conducted on all term and preterm newborns hospitalized for more than 35 weeks in Hajar Hospital affiliated with Shahrekord Medical University in 2012- 2013. Using two- range sampling test, out of 130 babies admitted to the hospital, 130 newborns were selected randomly.

Subjected were divided into two groups of similar size. Sixty five newborns with Total Serum Bilirubin (TSB) >220 mm/dl (D12.9 mg/dl) were assigned to LED phototherapy group and 65 newborns with TSB above 300 mm/dl (17.6 mg/dl) during phototherapy were excluded from the study and received intensive phototherapy. Any subject with the following criteria were excluded: TSB more than 17.6 mg/dl, received phototherapy prior to hospital admittance, mother and the newborn took phenobarbital, Jaundice was due to hemolytic diseases, ABO discrepancy, and RH disorders, a subject which needed to be taken care of in The Neonatal Intensive Care Unit (NICU), Owing to change in general health conditions, subjects underwent sepsis workup.

After developing a special questionnaire and applying it, history taking, interviewing parents, and precise clinical examination, data were collected and recorded. These included weight, sex, delivery type, age in hours, and nutrition through breast feeding, history of phototherapy of siblings, phototherapy prior to admittance, RH and ABO disorders, and glucose-6-phosphate dehydrogenase (G6PD) enzyme. Upon dividing the subjects into the two groups, TSB was measured at admittance, and 6, 12, 24 hours after admission and was recorded. Also TSB level and phototherapy duration were also recorded at hospital discharge time.

Reliability and validity of the questionnaire were set based on guidelines of the American Pediatric Society designed according to Butani monogram and were confirmed by determining TSB levels in the danger zone (15).

Demographic data and the necessary background variables including weight, sex, delivery type, age, feeding type, were recorded after simple sampling. Then, TSB levels at admission, six, twelve, and twenty–four hours after phototherapy, the last TSB levels, and phototherapy duration, were recorded. In the control group, 69 newborns were first studied; and three for ABO discrepancy and one for G6PD enzyme deficiency were excluded. In the intervention group, 71 newborns were studied initially; four for ABO discrepancy and two for G6PD deficiency due to TSB levels exceeding 17.6 and needing intensive phototherapy, were excluded. Data were analyzed with the use of SPSS 18.

Results

Findings indicated that mothers' pregnancy mean age was 38.05-0.94 weeks. Cesarean type of childbirth was commoner than natural birth. Fifty-eight subjects (44.6%) were female and 72 (55.4%) were male. Mean and Standard Deviation (SD) for weight were 3.58- 0.323.

Mean and SD of weight for newborns with jaundice were 89.51-17.06. To achieve two identical groups, chi- square and independent t-tests were applied ($p<0.05$). The results of paired t-test on TSB (mg/dl) reduction before and after conventional phototherapy revealed that in all three measurements, conventional phototherapy had reduced neonatal jaundice. The greatest reduction occurred in the last measurement (between12-24hours) and the least between 6-12 hours (Table 1).

Table 1: Demographic characteristics of samples in different therapeutic groups

Variable		LED N(percentage) MEAN±SD	Routine N(percentage) MEAN±SD	p-value
Habitat	village city	27(41.5) 38(58.5)	22(33.8) 43(66.2)	0.469
Delivery type	natural Cesarean	29(44.6) 36(55.4)	31(47.7) 34(52.3)	0.860
Sex	girl Boy	32(49.2) 33(50.8)	26(40.0) 39(60.0)	0.378
Mother blood group	A B AB O	21(32.3) 17(26.2) 3(4.6) 24(36.9)	20(32.8) 13(21.3) 7(11.5) 21(34.4)	0.557
Infant blood group	A B AB O	16(24.6) 7(10.8) 3(4.6) 39(60.0)	12(19.7) 20(32.8) 1(1.6) 28(45.9)	0.018*
Weight (gr)		3032.31±331.01	3085.08±315.69	0.354
Gestational age (week)		38.08±1.00	38.03±0.88	0.781
Age (hours)		86.09±15.02	92.94±18.37	0.022*
1 min. Apgar		8.66±0.51	8.77±0.42	0.192
5 min. Apgar		9.68±0.50	9.77±0.42	0.261
Start of jaundice		62.00±11.14	69.75±13.81	0.001**

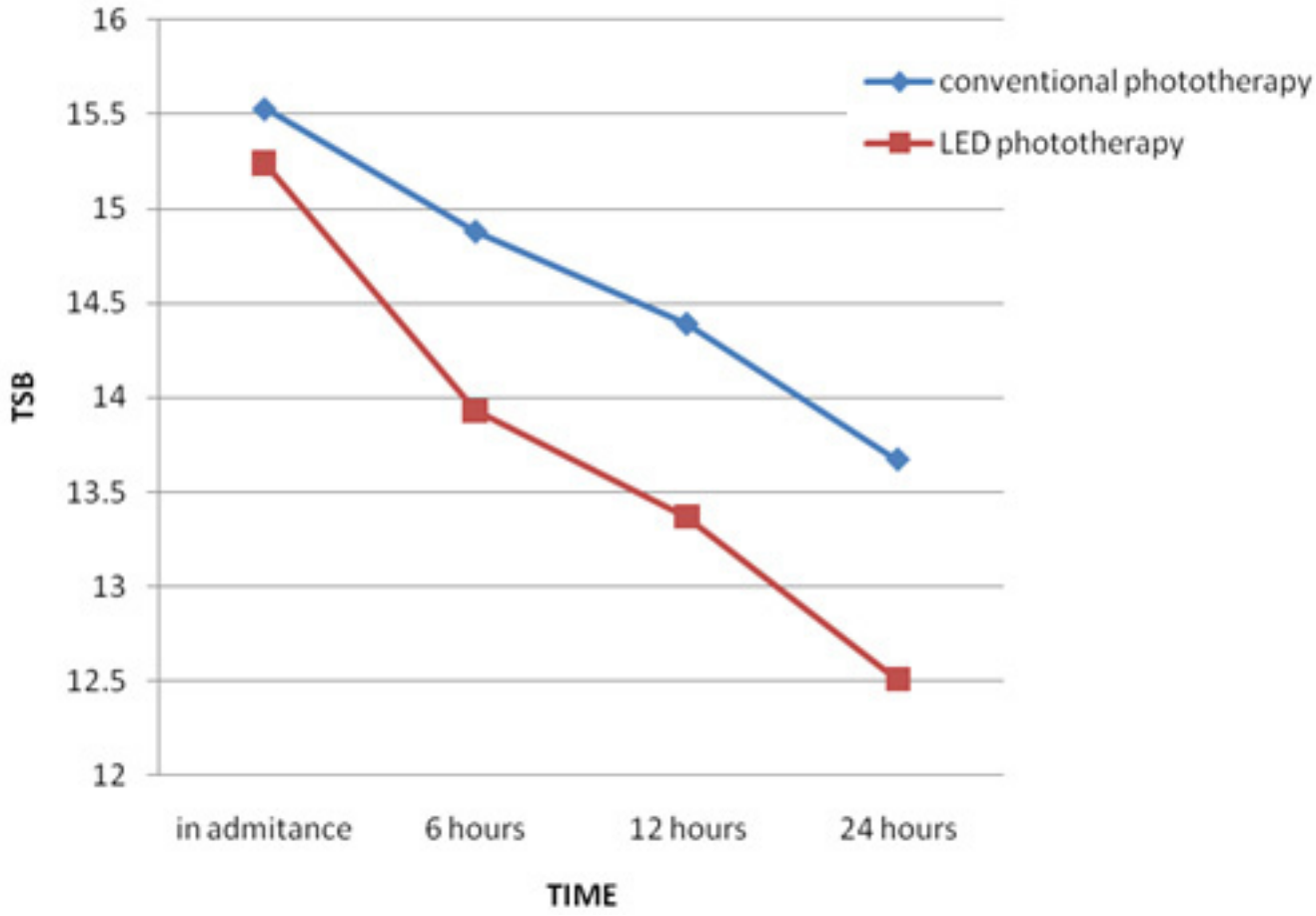
*P<0.05; **P<0.01

Results of repeat measurement show significant differences in TSB at different times and that was descending. (F= 360.591 df=1.473 P-value=0.000). Also TSB was significantly lower in the LED phototherapy group. (F= 19.240 df=1 P-value=0.000). TSB was significantly lower in the LED group at all times and with a more descending rate in this group. (F= 14.603 df=1.473 P-value=0.000). (Table 2, Chart 1)

Table 2: Results of TSB in LED and Routine phototherapy

TSB	LED MEAN±SD	Routine MEAN±SD	P-value
Admission time	15.24±1.17	15.53±1.32	p>0.05
At 6 hours	13.93±1.86	14.88±1.17	P<0.05
At 12 hours	13.37±0.92	14.39±1.12	P<0.05
At 24 hours	12.51±0.82	13.67±1.08	P<0.05

Chart 1: Mean TSB in two groups in different times



Results of repeated measure test at different times:

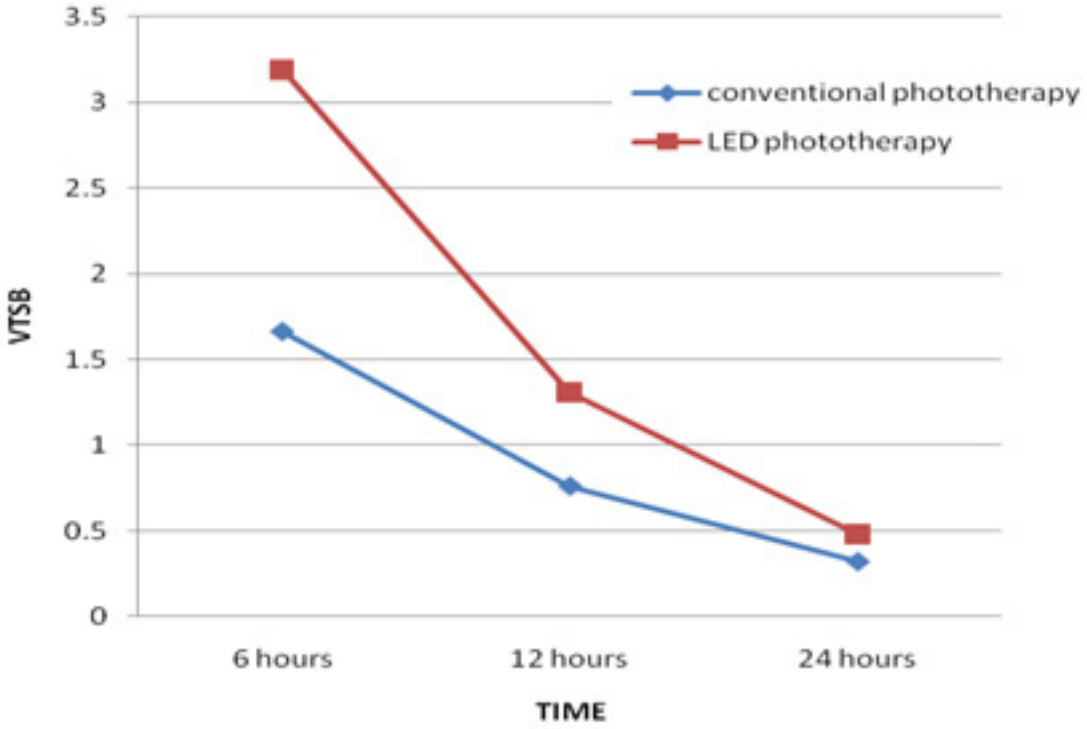
TSB has a descending rate and significantly different rate in all times (F= 114.892 df=1.050

P-value=0.000). TSB was significantly different in the two groups and was higher in the LED phototherapy group. (F= 137.382 df=1 P-value=0.000). TSB changes were more in the LED group and had a greater descending rate in the LED group (F= 14.603 df=1.473 P-value=0.000) (Table 3, Chart 2).

Table 3: Results of TSB changes in two groups

TSB	LED MEAN±SD	Routine MEAN±SD	Total
At 6 hours	3.19±0.96	1.66±0.54	P<0.05
At 12 hours	1.31±0.38	0.76±0.19	P<0.05
At 24 hours	0.48±0.10	0.32±0.06	P<0.05

Chart 2: Mean VTSB in two groups in different times



Discussion

In order to investigate TSB levels before and after inventions, paired t-test was applied. The findings showed that in all three measurements, LED phototherapy had effectively reduced TSB levels. The highest reduction occurred in the last measurement (between 12 and 24 hours) and the lowest occurred in the measurement between 6 and 12 hours. The conventional phototherapy also reduced TSB levels in all three measurements. The highest reduction happened in the first measurement (between 0 and 6 hours) and the lowest in the measurement between 6 and 12 hours. In the randomized controlled trial by Martins et al. on preterm neonates, comparing indium gallium nitrate LEDs with halogen phototherapy, results showed greater decrease in TSB levels and shorter duration of phototherapy in the LEDs group. These results could be attributed to the lesser irradiance of halogen lamps and broad spectrum of light emitted by them in comparison to LEDs. [16]

Independent t-test was applied for the comparison of neonatal jaundice at hospital admission, six, twelve, twenty-four hours later, at discharge time, TSB levels changes at those times, and finally time spent on phototherapy.

Findings showed there was no significant difference in TSB at hospital admittance time ($p=0.05$), but 6, 12, and 24 hours after the invention, there was a significant difference in TSB levels in the two groups. In fact, LED phototherapy reduced TSB levels more than the conventional method. The results of Mohammadizadeh study showed that LED light source is as effective as fluorescent tubes for the phototherapy of preterm infants with indirect hyperbilirubinemia(17).

Regarding time spent on phototherapy, findings showed in LED phototherapy less time had been spent. As for TSB levels at particular times after the invention, findings indicated there was a significant difference between the two interventions ($p <0.05$). It was also noticed that TSB reduction slowed down with the passage of time and the reduction was more when LED phototherapy was used. Bertini and colleagues showed that conventional phototherapy units result in a significant increase of trans-epidermal water loss in preterm infants, and this side effect was not observed with LED units. [18]

The findings are similar to those of a study by Maisels et al. conducted in 2007 in Turkey, and Sheng in 2012 (7 ,11). These studies suggest that there is a significant difference in phototherapy duration and efficiency between LED and conventional phototherapy. However, in a study by Kurmar P et al. in 2010 in India and also another study by Kurmar P et al in 2011 in India it was shown that there was no significant difference in neither TSB reduction speed nor phototherapy, which is not similar to the findings of the present study (12, 19). The dissimilarity could be due to different sample size, different races of the subjects, and application of first generation LED phototherapy devices rather than the newer super LED lamps in those studies. Also, one difference between the present study and those conducted by Karago et al. in Turkey (20) and Maisels MJ et al. in America (6) was that TSB levels were measured 6, 12, and 24 hours after hospital admittance, and therefore could provide a more precise judgment about TSB reduction speed TSB changes in different time periods.

Conclusion

LED phototherapy produces less heat, is free from infrared and ultraviolet rays, consumes less wattage, is less bulky, has longer lamp life, and is easier to use. The benefits make the technique qualified as a recommended phototherapy method. However, the high cost of the devices is a big disadvantage that should also be considered.

References

1. Kliegman RM, Stanton B, Richard E, Behrman R. Nelson textbook of pediatrics. 19th ed. USA: Saunders Elsevier; 2012.
2. Rodrigues DL. Phototherapy for neonatal jaundice treatment, Compendium of new and emerging technologies that address global health concerns 2011 Brazil: World Health Organization; 2016 [cited 2016 11 Jan]. Available from: http://www.who.int/medical_devices/innovation/new_emerging_tech_33.pdf.
3. Bhutani VK, Wong RJ. Bilirubin Neurotoxicity in Preterm Infants: Risk and Prevention. Journal of Clinical Neonatology. 2013;2(2):61-9.
4. Hansen TW. Prevention of neurodevelopmental sequelae of jaundice in the newborn. Dev Med Child Neurol. 2011;53 Suppl 4:24-8.
5. Cloherty JP, Eichenwald EC, Stark AR. Manual of neonatal care. 17th ed. USA: Lippincott Williams & Wilkins; 2011.
6. Maisels MJ, McDonagh AF. Phototherapy for neonatal jaundice. New England Journal of Medicine. 2008;358(9):920-8.
7. Maisels MJ, Kring EA, DeRidder J. Randomized controlled trial of light-emitting diode phototherapy. J Perinatol. 2007;27(9):565-7.
8. Ebrahimimd S, Ashkani-Esfahani S, Poormahmudibs A. Investigating the Efficacy of Zizyphus Jujuba on Neonatal Jaundice. Iranian Journal of Pediatrics. 2011;21(3):320-4.
9. Najib KS, Saki F, Hemmati F, Inaloo S. Incidence, Risk Factors and Causes of Severe Neonatal Hyperbilirubinemia in the South of Iran (Fars Province). Iranian Red Crescent Medical Journal. 2013;15(3):260-3.
10. Ip S CM, Trikalinos T, et al. Screening for Bilirubin Encephalopathy [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2009 Oct. (Evidence Syntheses, No. 72.) Appendix C., Combined Evidence Tables. USA: NCBI; 2016.
11. Sheng Wu Yi Xue, Gong Cheng XueZaZhi. Development of a portable high-power light-emitting diode phototherapy system for neonatal jaundice. Journal of Biomedical Engineering. 2012; 29(1):89-92
12. Kumar P, et al. Light-emitting diodes versus compact fluorescent tubes for phototherapy in neonatal jaundice. Indian Pediatrics.2010; 47:131-7.
13. Yun Sil Chang, Jong Hee Hwang, et al. In vitro and in vivo efficacy of new blue light emitting diode phototherapy compared to conventional halogen quartz phototherapy for neonatal jaundice. Journal of Korean medical science. 2005; 20(1):61-64
14. Bianca M.R Martins, M de carvallo, et al. Efficacy of new micro-processed phototherapy system with five high intensity light emitting diodes (super LED). Journal de pediatric. 2007, 83(3): 253-258.
15. Viau Colindres J, Rountree C, et al. Prospective randomized controlled study comparing low-cost LED and conventional phototherapy for treatment of neonatal hyperbilirubinemia. Journal Trop pediatria. 2012; 58(3):178-83.
16. Martins BM, de Carvalho M, Moreira ME, Lopes JM. Efficacy of new microprocessed phototherapy system with five high intensity light emitting diodes (Super LED) J Pediatr (Rio J) 2007;83:253–8.
17. Mohammadizadeh M, Kadkhodaei F and Badiei Z. Is the light-emitting diode a better light source than fluorescent tube for phototherapy of neonatal jaundice in preterm infants? Adv Biomed Res. 2012; 1: 51.
18. Bertini G, Perugi S, Elia S, Pratesi S, Dani C, Rubaltelli FF. Transepidermal water loss and cerebral hemodynamics in preterm infants: Conventional versus LED phototherapy. Eur J Pediatr. 2008; 167:37–42.
19 Kumar P, Murki S, Malik GK, Chawla D, Deorari AK, Karthi N, et al. Light emitting diodes versus compact fluorescent tubes for phototherapy in neonatal jaundice: a multi-center randomized controlled trial. Indian Pediatrics 2010;47(2):131-7.
20. Karagol B S, Erdeve O, Atasay B, Arsan S. Efficacy of light emitting diode phototherapy in comparison to conventional phototherapy in neonatal jaundice. Ankara university faculty of medicine 2007; 60(1):31-34.