# Effectiveness of 360° Intensive Phototherapy versus Conventional Phototherapyfor Neonatal Hyperbilirubinemia

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## تأثير العلاج الضوئي ب ٣٦٠ درجة مقارنة بالعلاج الضوئي التقليدي في علاج اليرقان الولادي

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**الخلاصة:**

**خلفية** : فرط بيليروبين الدم مشكلة شائعة ، وفي معظم الحالات ، حميدة في حديثي الولادة. العلاج بالضوء هو الدعامة الأساسية لعلاج فرط بيليروبين الدم ، ويتوقف مدى فعالية العلاج بالضوء على طيف الضوء (الطول الموجي) ، تدفق للضوء ، ومساحة سطح الرضع المعرضين للضوء. ان مقياس مدى فعالية العلاج بالضوء هو الانخفاض الكبير في عدد عمليات تبديل الدم التي يتم تنفيذها.

**الأهداف** : الهدف من هذه الدراسة هو تقييم فعالية زيادة المساحة السطحية للعلاج الضوئي الى (٣٦٠ ◦) مقارنة مع العلاج الضوئي التقليدي بسطح واحد فلوري في علاجhyperbirubinemia في حديثي الولادة ، وانخفاض معدل عمليات تبديل الدم.

**المرضى والطريقة** : ما مجموعه ٧٣ طفل حديث الولادة مصابباليرقان بنسبة اكثر من٥٠ ٪ من الحد الاعلى للبيليروبين (TSB) تم ادخالهم في الدراسة ، كانوا مكتملي عمر الحمل او اقرب للاكتمال.وفقا لمستوى بيليروبين الدم وتوافر العلاج الضوئي المكثف للغاية تم تقسيم الحالات الي مجموعتين. المجموعة الأولى : ٣٧ مولود جديد تلقى العلاج الضوئي التقليدي والمجموعة الثانية تشمل ٣٦ مولود جديد تلقى العلاج الضوئي المكثف للغاية ٣٦٠ درجة.

**النتائج :** كان مستوى البيليروبين الابتدائي في المجموعة الاولى2.6 ± 14.5 بينما في المجموعة الثانية ٢٠.٦ ± ٣.٧٤ ، وكان الفرق يعتد به إحصائيا (P<٠.٠٠١) ، وكان أيضا كبيرا لمستوى البيليروبين النهائي (p = ٠.٠٠٤). كان الفرق في البيليروبين1.1 ± 1.8 ملغ / دل للمجموعة الاولى و ٥.٥ ± ٣.١٠ ملغ / دل عن المجموعة الثانية (p<٠.٠٠١) ، ومدة العلاج بالضوء اللازمة في كل من المجموعتين كان ٨.٦ ± ٢.٢ ساعة للمجموعة الاولى و ٤.١ ± ١.٢٥ ساعة لمجموعة الثانية (P<٠.٠٠١).وكان معدل الانخفاض في 0.2 ملغ لكل ساعة في المجموعة الاولى بينما في المجموعة الثانية ١.٣ ملغ لكل ساعة و الفرق يعتد به إحصائيا (P<٠.٠٠١) . كان هناك انخفاض كبير في عدد عمليات تبديل الدم في عام ٢٠١٠ (P<٠.٠٢٦) عندما بدأ استخدام العلاج الضوئي المكثف ٣٦٠ درجة.

**الاستنتاج :** زيادة مساحة العلاج الضوئي المكثف إلى ٣٦٠ درجة أكثر فعالية من العلاج الضوئي التقليديبسطح واحد في خفض مستوى البيليروبين في علاج فرط بيليروبين الدم. وقد انخفض عدد عمليات تبديل الدم كثيرا عندما بدأ العلاج الضوئي المكثف في علاج يرقان الأطفال حديثي الولادة.

**Abstract:**

***Background:***Hyperbilirubinemia is a common and, in most cases, benign problem in neonates.Phototherapy is the mainstay of treatment of hyperbilirubinemia, The efficacy of phototherapy depended on the light spectrum (wavelength), flux of light, and surface area of the infant exposed to phototherapy. A measure of the efficacy of phototherapy is the dramatic reduction in the number of exchange transfusions being performed.

***Objectives:***The aim of this study was to evaluate the efficacy of increased surface area of phototherapy (360 ◦) compared with conventional single surface fluorescent phototherapy in the management of neonatal hyperbirubinemia, and in decreasing the rate of exchange transfusion.

***Patients and Method:***A total 73 neonates present with significant jaundice 50 % of the maximal total serum bilirubin (TSB) level and need phototherapy were included in the

study, they were term and near term. According to the level of TSB and availability of highly intensive phototherapy the cases divided in to tow groups. First group: 37 newborns who received conventional phototherapy and the second group include 36 newborns who received highly intensive 360 ° phototherapy.

***Results:***The mean starting TSB in group 1 was 14.5 ± 2.6 while in group 2 20.6 ± 3.74 and it was statistically significant ($p<0.001$) and it was also significant for ending TSB ($p=0.004$). The TSB difference in bilirubine was 1.8 ± 1.1 mg/dl for group 1 and 5.5 ± 3.10 mg/dl for group 2 ($p<0.001$), and the duration of phototherapy needed in both groups was 8.6 ± 2.2 hr for group 1 and 4.1 ± 1.25 hr for group 2 ($p<0.001$). The decline rate in group1 was 0.2 mg per hour while in group 2 was 1.3 mg per hour which was statistically significant ($p<0.001$), there was a significant decline in the number of exchange transfusion in 2010 ($p<0.026$) when the highly intensive 360 degree phototherapy started to be used.

***Conclusion:*** Increasing surface area of intensive phototherapy to 360 degree was more effective than single-surface conventional phototherapy in reducing bilirubin level in the treatment of hyperbilirubinemia. Exchange transfusion rate was much decreased when highly intensive phototherapy was started in the management of neonatal jaundice.

## Introduction:

Hyperbilirubinemia is a common and, in most cases, benign problem in neonates. Jaundice is observed during the 1st wk of life in approximately 60% of term infants and 80% of preterm infants. The yellow color usually results from the accumulation of unconjugated, nonpolar, lipid-soluble bilirubin pigment in the skin[(1)]. Because of the potential toxicity of bilirubin, newborn infants must be monitored to identify those who might develop severe hyperbilirubinemia and, in rare cases, acute bilirubin encephalopathy or kernicterus[(2,3,4)]. Phototherapy is the mainstay of treatment of hyperbilirubinemia,[(2)]its clinical efficacy having been confirmed in many studies [(5,6,7)]. The efficacy of phototherapy depended on the light spectrum (wavelength), flux of light, and surface area of the infant exposed to phototherapy[(8,9,10)].

There is lack of consensus regarding the exact bilirubin level at which to initiate phototherapy. Phototherapy is usually started at 50–70% of the maximal indirect level[(1)].The AAP treatment guidelines are summarized in 2 figures, 1 for phototherapy and 1 for exchange transfusion. Each figure has TSB treatment threshold lines for infants in different risk groups, defined by gestational age (<38 weeks or <38 weeks) and the presence of hemolysis or other signs of significant illness, clinicians can determine whether the AAP recommends phototherapy or consideration of exchange transfusion[(2,11)]. The use of phototherapy has decreased the need for exchange transfusion in term and preterm infants with hemolytic and non-hemolytic jaundice.AAP recommended intensive phototherapyin which the irradiance was more than 30 µw/cm2/nm for treatment of hyperbilirubinemia infants[(2)].the use of high-intensity phototherapy to ensure greater effectiveness and a faster rate of decrement in bilirubin levels would be useful [(5)].Over the last 2 decades, there has been a constant endeavor to develop ways to increase the efficacy of phototherapy and at the same time reduce the side-effects and disadvantages to nursing personnel[(12)] .

Many studies assess the effectiveness of different types of intensive phototherapy such as single layer and double layer , fiberoptic and light emitting diodes as compared with conventional phototherapy[(5,7,8,9,10,12,13)].

Since the only effective alternative to phototherapy in infants with severe jaundice is exchange transfusion, a measure of the efficacy of phototherapy is the dramatic reduction in the number of exchange transfusions being performed.[14,15,16].
Whenpositioned 20 cm above the infant, conventional orstandard daylight phototherapy units should delivera spectral irradiance (measured at the level ofthe infant) of 8 to 10 μW per square centimeter pernanometer in the 430-to-490-nm band, whereasspecial blue fluorescent lamps will deliver 30 to40 μW per square centimeter per nanometer.[17]
The aim of this study was to evaluate the efficacy of increased surface area of phototherapy
(360 °) compared with conventional single surface fluorescent phototherapy in the management of neonatal hyperbirubinemia, and in decreasing the rate of exchange transfusion.

## Patients and Method:

A prospective controlled trial was conducted in the Neonatal care unit in Al-Zahraa teaching hospital in AnNajaf city from January 2010 to June 2010.
A total 73 neonates present with significant jaundice 50 % of the maximal total serum bilirubin (TSB) level[1] and need phototherapy were included in the study, they were term and near term. According to the level of TSB and availability of highly intensive phototherapy the cases divided in to tow groups. First group: 37 newborns who receivedconventional phototherapy and the second group include 36 newborns who received highly intensive 360 °phototherapy.
A capillary blood sample was taken from each newborn baby by heparinized capillary tube by pricking the heal then put in the micro centrifuge for 5 minute at 5000 round per minute then TSB measured by a ( Bilirubin Meter, from EAMA B- 105N) at start and at the end of phototherapy.
The conventional phototherapy consisting of 3 deep blue and 3 daylight (Philips TL 20W/52) fluorescent tubewithin 40 cm from the infant.The intensive 360 ° phototherapy provided by 16 (TL 20W/52) fluorescent tube in a 360 degree within 20 cm from the infant( CRADELE 360 device from Mediprema manufacturer ).
Breast feeding was incauraged throughout the phototherapy period. The newborn in both groups wore eye patches and disposable diapers folded to allow maximum skin exposure to phototherapy. Phototherapy was administered continuously except for miner procedures such as feeding, physical examination and taking capillary blood samples. Phototherapy discontinued when the TSB reached below 50% of the maximal TSB level[1]and at different time period in both groups.
The results were analyzed using the SPSS version 17.0 software and are reported as a mean ±the standard deviation (SD). Unpaired t-test was used to test the different between mean ± SD and pearson correlation. The p-value $< 0.05$ was defined as statistically significant.

## Results

37 newborns were included in group 1 who receive conventional phototherapy and 36 newborns in group 2 who receive highly intensive phototherapy. The mean age of group 1 was 5.7 ± 2.6 days while in group 2 was 6 ± 2.99 without statistical difference which was not significant also for onset of jaundice appeared and body weight in both groups as shown in table 1. The mean starting TSB in group 1 was 14.5 ± 2.6 while in group 2 20.6 ± 3.74 and it was statistically significant ($p<0.001$) and it was also significant for

ending TSB (p=0.004). The TSB difference in bilirubine was 1.8 ± 1.1 mg/dl for group 1 and 5.5 ± 3.10 mg/dl for group 2 (p<0.001), and the duration of phototherapy needed in both groups was 8.6 ± 2.2 hr for group 1 and 4.1 ± 1.25 hr for group 2 (p<0.001). The decline rate in group1 was 0.2 mg per hour while in group 2 was 1.3 mg per hour which was statistically significant (p<0.001), as shown in table 1.

**Table 1: Clinical and laboratory data of study groups**

| | group 1 | group 2 | P value |
|---|---|---|---|
| | Mean ± Std. Dev | Mean ± Std. Dev | |
| **Age of newborns(days)** | 5.7 ± 2.6 | 6 ± 2.99 | 0.638 |
| **Onset of jaundice(days)** | 2.9 ± 1.2 | 3 ± 1.26 | 0.674 |
| **Body weight(kg)** | 2.92 ± 0.682 | 2.94 ± 0.680 | 0.858 |
| **Starting TSB(mg/dl)** | 14.5 ± 2.6 | 20.6 ± 3.74 | <0.001 |
| **Ending TSB(mg/dl)** | 12.8 ± 2.9 | 14.9 ± 3.25 | 0.004 |
| **TSB Difference(mg/dl)** | 1.8 ± 1.1 | 5.5 ± 3.10 | <0.001 |
| **Phototherapy Duration(hr.)** | 8.6 ± 2.2 | 4.1 ± 1.25 | <0.001 |
| **TSB decline rate (mg/dl/ hr)** | 0.2 | 1.3 | < 0.001 |

The male to female ratio in group 1 was 21/16 and in group 2 it was 22/14, the difference was statistically not significant. The mode of delivery was 17 to 21 by CS in group 1 and 18 /17 in group 2 which was statistically not significant. 29 neonates born at term and 7 preterm in group while in group 2 it was30 / 7 which was statistically significant, as shown in table 2.

**Table 2: Frequency of Sex, Mode of delivery and GA in the study groups**

| | | Group 1 | | Group 2 | |
|---|---|---|---|---|---|
| | | **Frequency** | **Percent** | **Frequency** | **Percent** |
| **Sex** | **Male / female** | 21 / 16 | 56.8 / 43.2 | 22 / 14 | 59.5 / 37.8 |
| **Mode of delivery** | **Normal / CS** | 17 / 20 | 45.9 / 54.1 | 18 / 17 | 48.6 / 45.9 |
| **GA** | **Term / preterm** | 29 / 7 | 78.4 / 18.9 | 30 / 6 | 81.1 / 16.2 |

The correlation between the starting TSB and the duration of phototherapy was not significant in Group 1( p = 0.994), and it was significant in Group 2 (p= 0.003), as shown in table 3.

**Table 3: Correlation between starting TSB and duration of phototherapy in both groups**

| | group 1(37) | group 2(36) |
|---|---|---|
| **Pearson Correlation** | 1(0,001) | 1(0,487) |
| **Sig. (2-tailed)** | .994 | 0.003** |
| ****. Correlation is significant at the 0.01 level (2-tailed).** | | |

The number of exchange transfusion was reviewed in first 6 months of 2008, 2009 and 2010 which showed that there was a significant decline in the number of exchange transfusion in 2010 (p<0.026) when the highly intensive 360 degree phototherapy started to be used in the neonatal care unit, as shown in table 4.

**Table 4: Rate of exchange transfusion during the first 6 months of the last three years.**

| | Sum | Mean | Std. Deviation |
|---|---|---|---|
| **First 6 months of Year 2008** | 95.00 | 15.8333 | 14.28869 |
| **First 6 months of Year2009** | 124.00 | 20.6667 | 11.57008 |
| **First 6 months of Year2010** | 35.00 | 5.8333 | 6.64580 |

**P value = 0.026 (independent t test)**

## Discussion :

In general, if the infants became significantly jaundiced, they were treated with single-surface phototherapyand if the infants did not respond, the further treatments were increasing phototherapy unit beside or beneath the infant or exchange transfusion.[13]This is what was used in this neonatal care unite until new intensive 360 degree with special blue light fluorescent tube used since the beginning of 2010. Newborns with high TSB near or over 20 mg/dl was put under highly intensive phototherapy for 4 hours and those with less severe readings put under the usual phototherapy. This explain that the mean initial TSB for group 1 (no. 37) was 14.5 ± 2.6 mg/dl while in group 2 (no. 36) was 20.6 ± 3.74 with significante difference ($p<0.001$).

The objectives of this study were to assess the effectiveness of using the intensive phototherapy in decreasing the bilirubine level in shorter time and how it was affect the rate of exchange transfusion in the management of neonatal hyperbilirubinemia.

It was found that the mean difference of TSB between initial and final TSB in group 1 was 1.8 ± 1.1 mg/dl while in group 2 was 5.5 ± 3.10 mg/dl with significant difference ($p< 0.001$), and the rate of TSB reduction was 0.2 mg/dl/hr and for group 2 was 1.3 mg/dl/hr ( $p<0.001$).

The result of the present study was consistent with previous studies using double phototherapy compared with single phototherapy, but different in bilirubin reduction. Holtrop PC et al[9] found bilirubin reduction after 18 hours of double phototherapy was 2.9 ± 1.1 mg/dl and 1.6 ± 1.4 mg/dl from single phototherapy. The reduction rate of Holtrop's study was approximately 0.16 mg/dl/h, whereas the reduction rate of the present study was 1.3 mg/dl/h with360 degree phototherapy. SariciUmit S et al[18] demonstrated the efficacy of double phototherapy using standardphototherapy unit consisted of five special blue lampscombined with fiberoptic phototherapy pad beneaththe infant's body and the reduction rate of bilirubinwas 1.29 ± 0.38%/h more than that in single phototherapy(1.02 ± 0.22%/h, which was the same in this study (1.3 mg/dl/hr) but less than Payon B et al [13] study who found rate was (1.42%/h)with double-surface intensive phototherapy. The differences of bilirubin reduction in the present study from the previous studies were probably due to the difference of the irradiance of the light, type of light sources and mainly due to increasing the surface are exposed to phototherapy around 360 degree and this fact proved by previous studies.[5,10,13,18,19,20]

The rate of exchange transfusion was decreased in first 6 months of 2010 (35)compared with 2009(124) and 2008(95) by 28 % and 36 % ( $p<0,026$), and this was obviously related to the use of highly intensive phototherapy which started at the beginning of 2010. This result consistent with previous studies which showed that when phototherapy was withheld, 36% of infants with birth weights of less than 1500 g required an exchange transfusion.[21]When phototherapy was used, only 2 of 833 such infants (0.24%) received exchange transfusions.[22]

**Conclusion:**

Increasing surface area of intensive phototherapy to 360 degree was more effectivethan single-surface conventional phototherapy in reducingbilirubin level in the treatment of hyperbilirubinemia. Exchange transfusion rate was much decreased when highly intensive phototherapy was started in the management of neonatal jaundice.

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