

COMPARATIVE STUDY OF THE SUPER LIGHT-EMITTING DIODE VERSUS CONVENTIONAL PHOTOTHERAPY IN NEONATAL JAUNDICE IN NICU IN ZAGAZIG UNIVERSITY HOSPITAL

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ABSTRACT

Background : In neonates, high levels of total serum bilirubin (TSB) can cause severe and irreversible brain damages. Thus, prompt diagnosis and treatment of indirect hyperbilirubinemia is of great importance in this age group. Phototherapy and exchange blood transfusion are two major therapeutic strategies to prevent bilirubin-induced brain damage in neonates. The choice of therapy depends on the severity of hyperbilirubinemia, but phototherapy is the most frequently used treatment .

Aim of the work: The aim of this study is to compare between the Super Light-Emitting Diode and Conventional Phototherapy in treatment of neonatal Jaundice.

Subject and method: Randomized controlled study were carried out at Zagazig university children's hospital on 28 neonate who were classified onto 2 groups .Both groups included preterm and full term neonates 14 subjected to conventional phototherapy and the other 14 subjected to super LED phototherapy .

Results :super LED is more effective than conventional phototherapy as mean TSB at admission on super LED was 18.5 mg/dl , after 6 hours from super LED phototherapy mean TSB became 15.5 mg/dl 35% from initial value and after 24 hours from phototherapy mean TSB became 10.93 mg/dl 50% of initial value After 24 h of treatment and normalization of serum bilirubin occurs after 30 hours. but mean TSB at admission on conventional phototherapy was 17 mg/dl , after 6 hours from conventional phototherapy mean TSB became 15,9 mg/dl ,and after 24 hours from phototherapy mean TSB became 13,8 mg/dl and normalization of serum bilirubin occurs after 47,5 hours.

Conclusion: Super LED phototherapy is more effective than conventional phototherapy devices as they can provide rapid reduction on high levels of hyperbillirubinemia .more time saving and less side effects.

Keywords: Total serum bilirubin, light emitting diode and Conventional phototherapy.

INTRODUCTION

In neonates, high levels of total serum bilirubin (TSB) can cause

severe and irreversible brain damages. Thus, prompt diagnosis and treatment of indirect hyper-

bilirubinemia is of great importance in this age group. Phototherapy and exchange blood transfusion are two major therapeutic strategies to prevent bilirubin-induced brain damage in neonates. The choice of therapy depends mainly on the severity of hyperbilirubinemia, but phototherapy is the most frequently used treatment [1]. The life span of LEDs is longer and their energy consumption is lower than that of the conventional light sources, which make them more cost-effective. Also, gallium nitride LEDs provide a narrow spectral band of monochromatic light with a special wavelength of 458 nm and high intensity, which overlaps the other light sources in phototherapy. absorption spectrum of bilirubin [2] Accordingly, LEDs are supposed to be more efficient than other phototherapy light sources. However, few available reports comparing the efficacy and safety of LED phototherapy with the conventional devices, only two of them used fluorescent tubes, and the results have been controversial. Also, there is no sufficient data for preterm infants in this regard. Some studies assessed and compared the efficacy and safety of LEDs with fluorescent phototherapy in the treatment of indirect hyperbilirubinemia

inemia in preterm and fullterm infants[3].

AIM OF THE WORK

The aim of this study is to compare between the Super Light-Emitting Diode and Conventional Phototherapy in treatment of neonatal Jaundice.

SUBJECT AND METHOD

This randomized controlled study was carried out on 28 neonates upon admission to Zagazig University children hospital Neonatal intensive care unit from the period of Dec. 2013 till Dec.2014 for neonatal jaundice. All neonate fulfill inclusion criteria admitted for hyperbilirubinemia who were classified onto 2 groups. Group I:14 neonate with hyperbilirubinemia and need phototherapy according to their TSB level and subjected to conventional fluorescent phototherapy as rescue treatment. Group II:14 neonate with hyperbilirubinemia and need phototherapy.

Inclusion criteria:

Neonates who fulfill the criteria for phototherapy as per American Academy of Pediatrics guidelines[4] Preterm and fullterm infants , Birth weight from 2 k.g to 4kg, Male and female and the two groups classified randomly, with

parents consent, ethical committee consent and no conflicted interest

Exclusion criteria: Patients previously received phototherapy. Patients with congenital malformations, infection, cholestasis (direct bilirubin > 2mg/dL) and Mother or newborn who received Phenobarbitone.

Performance and techniques: This study compared between the Super Light-Emitting Diode and conventional fluorescent tube on treatment of neonatal jaundice. The super LED device used in our study is Reverse and Reflected Microprocessed Phototherapy Of Super LEDs (BILITRON BED) model 4006, the modified LED-based phototherapy lamps are composed of Indium and Gallium Nitride (InGaN), were built from 84 3-mm high flux blue LEDs that emit a dominant wavelength of 450nm. The LEDs had a half-spectral width of 30nm. The LEDs were arranged in five strips of total number of 17 LEDs. Power is supplied so that if a single LED fails, the remaining LEDs still light. Every LED had filter covering which allow emitting blue light only and prevent other lights like yellow and green to be emitted. Also every LED had collimeter that condense blue light emitted. The peak irradiance at the center, 30cm from the lights is

between 35 and 40 $\mu\text{w}/\text{cm}^2/\text{nm}$. The illuminated area is 40 x 60 cm at a distance of 30cm from the lights. The other device used in our study was compact fluorescent tubes phototherapy (4 white lights 30 cm from above the neonates), with spectral irradiance of 8-12 microwatts/cm²/nm, wave lengths 430-490nm. All neonates subjected to :Complete history taking ,Complete physical examination, Temperature of the patients checked every four hours,Duration of phototherapy from beginning of admission till discharge ,The rate of decrease of total serum bilirubin concentration were recorded after 6 hours, 24 hours and till end of treatment, Laboratory investigation including taking Blood samples on postnatal days to identify Maternal and fetal blood groups, Hemoglobin level, Total serum bilirubin, direct and indirect levels at admission, 6 hours later and after 24 hour from admission, reticulocytic count and Coomb's test.

STATISTICAL ANALYSIS

All data were analyzed using SPSS 15.0 for windows (SPSS Inc., Chicago, IL, USA) & Med Calc 13 for windows (Med Calc Software bvba). Continuous data are expressed as the mean \pm SD & median (range), and the categorical data are expressed as a number

(percentage). Continuous data were checked for normality by using Shapiro-Wilk test. Independent Student t-test was used to compare two groups of normally distributed data. Mann-Whitney U (MW) test

was used to compare two groups of non-normally distributed data. Paired t test was used to compare normally distributed data between two dependent groups.

RESULTS

Table (1): Comparison between studied groups as regard demographic data.

Demographic data	Group I Conventional phototherapy (n=14)		Group II Super LED phototherapy (n=14)		Test	p
	No	%	No	%		
Sex					χ^2	
Female	5	35.7 %	5	35.7 %	0.156	0.693
Male	9	64.3 %	9	64.3 %		
Age (days)					MW	
Mean \pm SD	5.10 \pm 0.85		4.14 \pm 0.77		-2.587	0.010 (S)
Median (Range)	5 (3.5 – 6.5)		4 (3.5 – 5.5)			
Gestational age (weeks)						
Mean \pm SD	37.29 \pm 1.54		37.43 \pm 1.28		MW	0.886 (NS)
Median (Range)	38 (35 – 39)		38 (35 – 39)		-0.144	
Birth weight (gm)						
Mean \pm SD	3085.71 \pm 343.86		3028.57 \pm 360.40		t	0.671 (NS)
Median (Range)	3150 (2300–3600)		3100 (2300–3500)		0.429	
Mode of delivery						
NVD	4	26.6%	5	35.7%	χ^2	0.686 (NS)
CS	10	71.7%	9	64.3%		

Demographic data shows significant increase in age of patients of group I ,No. of females on this study was 10 and No. of males was 18 Mean gestational age of group I was (37.49 week) and mean gestational age of group II was (37.43 week), but there were no statistically significance as regarded gestational age, Mean birth weight for group I was (3085.71 gm) and mean birth weight for group II was (3028.57 gm) but there were no statistically significance as regarded to birth weight, Nine patients (32.15%) on this study was vaginally delivered and nineteen patients (67.85 %) was delivered by cesarean section, but their were no statistically significance as regarded to mode of delivery.

Table (2): Comparison between studied groups as regard to duration of phototherapy (hours).

Duration of phototherapy (hours)	Group I Conventional phototherapy (n=14)	Group II Super LED phototherapy (n=14)	t	p
Mean ± SD	47.35 ± 1.79	29.77 ± 1.03	31.822	<0.001 (HS)
Median (Range)	47.5 (44 – 50)	30 (28 – 32)		

As regarded duration of phototherapy, mean duration of phototherapy for group I was (47.35 hr) while for group II was (29.77 hr), there were significance between two studied groups, as the duration of phototherapy for group II was significantly shorter than duration of phototherapy for group I. Mean ± SD: (47.35 ± 1.79 Vs 29.77 ± 1.03), P< 0.001.

Table (3): Comparison between studied groups as regard to decrease of total serum bilirubin (mg/dl).

Total serum bilirubin (mg/dl)	Group I Conventional phototherapy (n=14)	Group II Super LED phototherapy (n=14)	t	p
Baseline Mean ± SD Median (Range)	17 ± 0.89 17 (16 – 19)	18.5 ± 0.73 18.5 (17 – 20)	-4.829	<0.001 (HS)
At 6 hours Mean ± SD Median (Range)	15.91 ± 1.22 15.95 (14 – 19)	15.5 ± 0.73 15.5 (14 – 17)	1.085	0.288 (NS)
At 24 hours Mean ± SD Median (Range)	13.84 ± 0.77 14 (12 – 15)	10.93 ± 0.87 11.05 (9.6 – 13)	9.320	<0.001 (HS)
At end of treatment Mean ± SD Median (Range)	(after 47.5 hours) 11.33 ± 1.01 11.25 (9.8 – 14)	(After 30 hours) 9.93 ± 0.87 10.05 (8.6 – 12)	3.921	0.001 (HS)
F•	235.416	1534.620		
P	<0.001 (HS)	<0.001 (HS)		

This table showed that mean baseline TSB level in group I was (17 mg/dl) and in group II was (18.5 mg/dl), there were statistically high significance difference between two groups $p < 0.001$, mean TSB level after 6 hours in group I was (15.91 mg/dl) and in group II was (15.5 mg/dl), there were no statistically significance difference between two groups ($p < 0.288$), but the baseline TSB level was statistically significant higher in group II than group I at admission, so after 6 hours Level of TSB in group II wasn't significantly different from group I. Laboratory finding showed that mean TSB level after 24 hours in group I was (13.84 mg/dl) and in group II was 10.93 mg/dl), there were statistically high significance different between two groups $p < 0.001$ Mean: $(13.84 \pm 0.77$ Vs $10.93 \pm 0.87)$ $p < 0.001$. and mean TSB level at end of treatment (after 47.5 hours) in group I was (11.33mg/dl) and (after 30 hours) in group II was 9.93 mg/dl), there were statistically high significance different between two groups $p < 0.001$. Mean \pm SD: $(11.33 \pm 1.01$ Vs $9.93 \pm 0.87)$ $P < 0.001$.

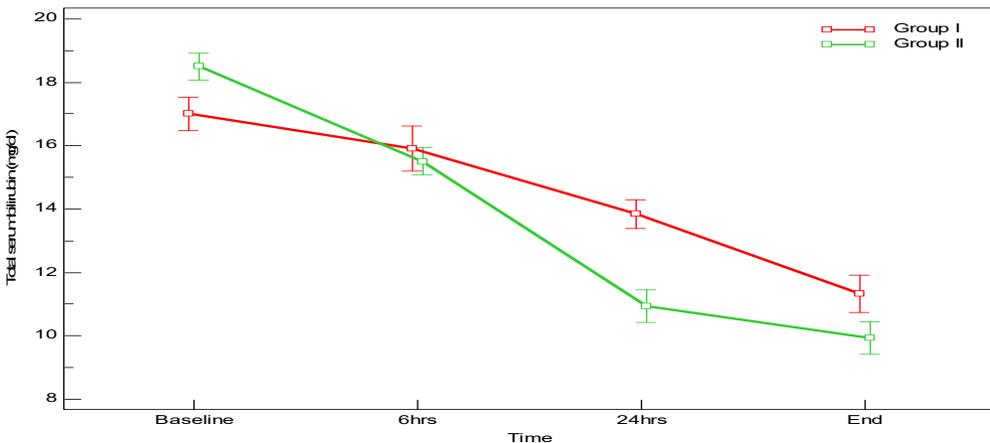


Fig (1): Shows comparison between studied groups as regard to decrease of serum billirubin.

Table (4): Comparison between studied groups as regard to change serum bilirubin (mg/dl/hr.) .

Change in total serum bilirubin (mg/dl/hr)	Group I Conventional phototherapy (n=14)	Group II Super LED phototherapy (n=14)	Test	p
Absolute change(mg/dl/hr)			MW	
Mean \pm SD	0.11 \pm 0.02	0.28 \pm 0.02	-4.540	<0.001 (HS)
Median(Range)	0.11 (0.05 – 0.14)	0.28 (0.25 – 0.34)		
Relative change after 6 hours(%/hr)			MW	
Mean \pm SD	1.19 \pm 0.26	2.66 \pm 0.20	-4.509	<0.001 (HS)
Median (Range)	1.09 (0.9 – 1.7)	2.7 (2.1 – 2.9)		
Relative change after 24 hours(%/hr)			t	
Mean \pm SD	0.76 \pm 0.13	1.70 \pm 0.14	-17.413	<0.001 (HS)
Median (Range)	0.77 (0.52 – 0.98)	1.68 (1.5 – 2)		

Absolute change in TSB: Change in serum bilirubin level before and after phototherapy divided to phototherapy duration (mg/dl/hour).

Relative change in TSB at 6 hour : percentage change in serum bilirubin level per hour after 6 hours of treatment

Relative change in TSB at 24 hour : percentage change in serum bilirubin level per hour after 24 hours of treatment.

DISCUSSION

Many studies have been conducted to compare between super LED and CFT phototherapy in treatment of neonatal jaundice, In our study we included Preterm and full term infants who have hyperbillirubinemia and need phototherapy. This randomized controlled study were carried out on 28 neonate who were classified onto 2 groups .Both groups included preterm and full term neonates 14 subjected to CFT and the other 14 subjected to super LED phototherapy .Demographic data as regarded age there was

significant increase in age of group I than patients on group II. As regarded to sex 64.3 % of neonates of our study was males and 35.7% was females but, there were no significance between two studied groups.As regarded to mode of delivery number of CS delivered neonates tends to be higher than normal vaginal delivered neonates between two studied groups (71.4% VS 64.3%) but the differences were not statistically significant.

In our study the results showed that there were statistical significance difference between two

studied groups as regarded to TSB at end of treatment ($p < 0.01$), as TSB level on CFT group was significantly higher in comparison with TSB level on super LED group (11.33 mg/dl VS 9.93 mg/dl) **table 3**. That goes along with study placed by BelmaSaygih et al. who studied 35 jaundiced infants, Twenty hyperbilirubine-mic neonates treated with conventional phototherapy (Group I) and 15 neonates treated with LED phototherapy (Group II) were retrospectively compared. their results showed that there were significant decrease in TSB at end of treatment[5], but it seems that our results was disagreed with study placed in Isfahan university by MajidMohammadizadeh et al., in Iran, on 64 infant who found that LED light source is as effective as fluorescent tubes for the phototherapy of preterm infants with indirect hyperbilirubiniemia. But this could be attributed to the baseline TSB on admission which was 8mg/dl, as phototherapy more effective on high bilirubin levels, also the difference between both groups in gestational age, There were also some limitations to Isfahan study The sample size of their study was not large enough to find small differences between LEDs and fluorescent phototherapy methods with regards to rate of fall of

bilirubin and duration of therapy[6]. Another study conducted by Seidman et al., on 69 jaundiced patient their result shows that the mean TSB concentrations at initiation and termination of treatment did not differ between newborns receiving LED and those receiving conventional phototherapy. The rate of decrease in TSB concentration were not statistically different in the 2 groups[7]. But this could be attributed to, that they were been using the blue gallium nitride LED device which had low light irradiance, their results disagree with our results. By looking to another Study conducted by Maisels et al., on randomly assigned 66 infant, their results showed that LED phototherapy is as effective as conventional fluorescent phototherapy in lowering serum bilirubin levels in term and near-term newborns[8], but this could be attributed to that they used low irradiance light source, which was disagree with our results. A prospective, randomized study by Johanna et al., included 45 pre-term neonates requiring phototherapy as per American Academy of Pediatrics guidelines, Their results showed that no statistically significant differences in the average bilirubin levels at the onset, at the maximum and at the end of treatment,

nor the rate of decrease in bilirubin levels in the neonates receiving conventional fluorescent blue light, conventional halogen light and LED phototherapy[9] but this could be attributed to many reasons. First, guidelines were used in making decisions about when to discontinue phototherapy, Second, Johanna's study did not take into account the time that patients were removed from phototherapy for hygiene, feeding and administration of medicines. Third, premature-sized diapers were not available for the participants; the standard-sized diapers covered a significant fraction of the abdominal surface area and this may have reduced light exposure, finally. The LEDs on Johanna's study illuminated an area of about 350 cm² at a distance of 25cm from the lights. The peak irradiance measured at the center of the illuminated area was 25 mW/cm², on the contrary on our study. The peak irradiance at the center, 30cm from the lights is 37 mW/cm². The illuminated area is 2400cm² at a distance of 30 cm from the lights. Our results were disagreed by Viau et al. who also studied 45 preterm their results didn't find any statistically significant difference between LED and conventional phototherapy [3] but there are many possible explana-

tions for this. First, this study did not take into account the time that patients were removed from phototherapy for hygiene, feeding and administration of medicines. Second, premature-sized diapers were not available for standard-sized diapers covered a significant fraction of the abdominal surface area and this may have reduced light exposure. As for the changes of Total serum bilirubin level after 24 hours from initiation of phototherapy in our study, our results showed that there was a statistically significant difference between two studied groups ($p < 0.001$), as TSB level of super LED group is significantly lower in comparison to TSB level of CFT group (13.84 mg/dl VS 10.93 mg/dl) That goes along with a study placed by B Martins et al., their results showed that after 24 hours of treatment, the decrease in total serum bilirubin levels was significantly greater in the super LED group [10]. The duration of phototherapy and the rate of decrease of total serum bilirubin (TSB) concentration in the first 24 hours of treatment were the main outcome measures. After 24 hours of treatment, the decrease in total serum bilirubin levels was significantly greater in the Super LED group (27.9 vs. 10.7%, $p < 0.01$). After 24 hours of treatment, a significantly greater

number of patients receiving Super LED phototherapy had reached serum bilirubin concentrations low enough to allow withdrawal of treatment (23 vs. 10, $p < 0.01$). That goes along with a study conducted by Chang et al., their results showed that the LED device showed significantly higher efficacy of bilirubin photodegradation than the conventional phototherapy [11]. As regarded to absolute change in serum bilirubin per hour, relative change in serum bilirubin after 6, 24 hours, there were statistically significance ($p < 0.01$) between two studied groups, this goes along with a study placed by Belma Saygih et al. whose results showed that 'Absolute' change and 'relative' percentage change in serum bilirubin levels were significantly higher on super LED group in comparison with CFT group [5]. As regarded to duration of phototherapy, there were significance between two studied groups ($P < 0.001$), as the duration of phototherapy for super LED group was significantly shorter than duration of phototherapy for CFT group (30 hours Vs 47.5 hours), this goes along with a study placed by Ngercham et al., on 40 patients divided on 2 groups, their result showed that LED group was significantly shorter duration of phototherapy

than conventional group [12]. This goes along with a study placed by Martins *et al.*, Their results showed that duration of phototherapy was significantly shorter in super LED group [11] This was disagreed by study placed by Kumar et al., on A total of 272 neonates were randomized to receive LED ($n=142$) or CFT ($n=130$) phototherapy their results showed that LED and CFT phototherapy units were equally efficacious in the management of non-hemolytic hyperbilirubinemia in healthy term and late-preterm neonates [2]. This could be attributed to Brief periods of discontinuation of phototherapy for feeding the baby or changing nappy were not excluded while calculating total duration of phototherapy.

Studies have agreed with our results in favor of super LED in being more effective and yields better results in decreasing TSB in short duration for treatment of neonatal jaundice of both term and preterm babies (Belma Saygih et al., Ngercham et al., and B Martins et al.). While others were completely the opposite which clarifies the need of more and more researches and studies on this matter (Johanna et al., Kumar et al., and Seidman et al.).

CONCLUSION

We conclude that the LED phototherapy more efficient than conventional phototherapy devices as they can provide rapid reduction in bilirubin photodegradation. Less side effects, time saving and efficient on high level of hyperbilirubinemia, so help in early discharge of jaundiced neonate from hospital, and this is desirable to keep infant maternal bond strong.

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دراسة مقارنة بين مصباح SUPER LED وجهاز الأشعة الضوئية العادية في علاج ارتفاع نسبة الصفراء عند الأطفال حديثي الولادة بوحدة المحضن في مستشفيات جامعة الزقازيق

المقدمة

مما لا شك فيه انه في علم حديثي الولادة زيادة نسبة الصفراء الكلية بالدم يمكن أن تسبب تدميرا شديدا ودائما بالمخ لذلك فان التشخيص والعلاج المناسب لارتفاع نسبة الصفراء الغير مباشره ذات أهمية شديدة لهذه الفترة العمرية والعلاج بالأشعة الضوئية وتغيير الدم هما الإستراتيجية الأساسية للعلاج لمنع التدمير الناتج عن ارتفاع نسبة الصفراء بالمخ اختيار العلاج يعتمد علي نسبة الصفراء بالدم ولكن العلاج بالأشعة الضوئية يظل هو الأكثر استخداما هناك جوانب إكلينيكية كثيرة من خصائص المصدر الضوئي منها الطول الموجي ونسبة الإشعاع المتناسب مع الجزء الظاهري من جسم الطفل وتعتبر المصادر الضوئية الأكثر استخداما هي الأنابيب المضيئة وأضواء الهالوجين وبالرغم من ذلك هذه المصادر الضوئية ذو أهمية محدودة علي سبيل المثال ينتج عنهم حرارة شديدة لا يمكن وضعها بالقرب من الأطفال ونلجأ لحل هذه المشكلة بواسطة عوازل توضع عند مصدر الضوء ولكنها غير فعالة تماما لصغر حجم المساحة المعرضة للأشعة الضوئية بسبب هذه التحديات أصبح مصباح الصمام الثنائي الباعث ينتج حرارة أقل لذلك يمكن وضعها بالقرب من الأطفال والفترة العمرية لمصابيح الصمام الثنائي الباعث أكثر وهي أقل استهلاكاً للطاقة من المصابيح الضوئية العادية وكذلك يجعلهم أكثر توفيراً للتكلفة.

تمت هذه الدراسة بوحدة المحضن في مستشفيات جامعة الزقازيق.

تضمنت الدراسة (28) حالة من الأطفال الذين يعانون من ارتفاع نسبه الصفراء تم تقسيمهم إلى مجموعتين:

المجموعة الأولى تضم 14 طفل يتم تعريضهم للأشعة الضوئية المكثفة العادية والمجموعة الثانية تضم 14 طفل يتم تعريضهم لمصابيح الضوء الثنائي الباعث).

مواصفات الأطفال في هذه الدراسة: الأطفال الذين ينطبق عليه شروط التعرض للأشعة الضوئية. الأطفال حديثي الولادة مكتملي النمو وناقصي النمو- وزن الأطفال ما بين 2

كجم إلى 4 كجم. ذكر وأنتي. خضع جميع الأطفال إلى الفحص السريري الكامل. تحاليل دم مثل نسبة هيमوجلوبين، نسبة صفرا كليه ومباشره وغير مباشرة (فى بداية العلاج وبعد 6 ساعات وبعد 24 ساعة وفى نهاية العلاج)، نسبة خلايا شبكية واختبار كومب والمدة الزمنية التي يستجيب فيها الطفل. من خلال هذه الدراسة توصل فريق البحث إلى أن مصابيح الصمام الثنائى الباعث أكثر كفاءة من مصابيح الأشعة الضوئية العادية لعلاج ارتفاع نسبة الصفراء عند الأطفال حديثي الولادة حيث انه ساعد فى تقليل نسبة الصفراء بالدم فى أول 24 ساعة من بداية العلاج. حيث انه توجد دلالات إحصائية ذات قيمة فى عدد ساعات العلاج مقارنة بين الجهازين حيث إن عدد ساعات العلاج كانت اقل كثيرا للمرضى اللذين تم علاجهم من خلال متوسط عدد ساعات العلاج على جهاز مصباح الصمام الثنائى الباعث 30 ساعة مقارنة بمتوسط عدد ساعات العلاج من خلال للمرضى اللذين تم علاجهم من خلال مصابيح الأشعة الضوئية العادية والتي كانت 47.5 ساعة. وكانت هناك دلالات إحصائية ذات قيمة فى التغيير فى نسبة الصفراء بالدم بين المجموعتين 1 و 2 حيث إن جهاز الصمام الثنائى الباعث استطاع تقليل نسبة الصفراء بالدم من متوسط 18.5 إلى 15,5 فى أول 6 ساعات من العلاج والى 10.9 فى 24 ساعة من العلاج مقارنة ب مجموعة 1 والتي تلقت العلاج من خلال جهاز الأشعة الضوئية العادية والذي استطاع تقليل نسبة الصفراء بالدم من متوسط 17 إلى 15 فى أول 6 ساعات من العلاج ثم إلى 13,8 فى أول 24 ساعة من العلاج. من خلال النتائج تبين أن جهاز الصمام الثنائى الباعث استطاع تقليل نسبة الصفراء بمعدل 0.5 مجم /ساعة وذلك فى خلال أول 6 ساعات وبمعدل 0.3 مجم/ ساعة وذلك فى خلال 18 ساعة التى تليهم وفى المقابل استطاع جهاز الأشعة الضوئية العادية تقليل نسبة الصفراء بمعدل 0.3 مجم / ساعة وذلك فى خلال أول 6 ساعات وبمعدل 0,06 مجم / ساعة وذلك فى خلال 18 ساعة التى تليهم. من خلال النتائج نقترح وضع الأطفال اللذين يعانون من ارتفاع شديد بنسبة الصفراء بالدم واللذين تم اتخاذ قرار بعلاجهم عن طريق تغيير الدم فى جهاز الصمام الثنائى الباعث لمدة ساعتين قبل القيام بتغيير الدم فى الفترة التى يتم بها تحضير الدم واستخدام مصابيح الضوء الثنائى الباعث بدلا من الأشعة الضوئية التقليدية.