International Journal Of

Recent Scientific Research

ISSN: 0976-3031

Volume: 7(3) March -2016

EFFECT OF PHOTOTHERAPY ON LEUKOCYTE COUNT IN NEONATES WITH HYPERBILIRUBINEMIA

Prabhakar N., Lazarus M and Verma AK

THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

ISSN: 0976-3031

Available Online at http://www.recentscientific.com

International Journal of Recent Scientific Research
Vol. 7, Issue, 3, pp. 9583-9587, March, 2016

International Journal of Recent Scientific Research

RESEARCH ARTICLE

EFFECT OF PHOTOTHERAPY ON LEUKOCYTE COUNT IN NEONATES WITH HYPERBILIRUBINEMIA

Prabhakar N[1]*., Lazarus M[2] and Verma AK[3]

[1,2]Department of Pediatrics, NSCB MCH Jabalpur, Madhya Pradesh, India
[3]Medical Officer, District Hospital Mandsaur Madhya Pradesh. India

ARTICLE INFO

Article History:

Received 15th December, 2015
Received in revised form 21st January, 2016
Accepted 06th February, 2016
Published online 28th March, 2016

Keywords:

Indirect hyperbilirubinaemia, Total leukocyte count, Phototherapy, Neonate.

ABSTRACT

Objective: To evaluate the effect of phototherapy on total leukocyte count in neonates with hyperbilirubinemia.
Design: Prospective observational study.
Setting: Pediatric department of a tertiary care teaching hospital.
Methods: 96 apparently healthy neonates who developed indirect hyperbilirubinaemia and required phototherapy irrespective of gestational age and birth weight included in the study. Neonates having septicemia, congenital porphyria or a family history of porphyria, conjugated hyperbilirubinaemia and receiving concomitantly drugs or agents that are photosensitizers were not included in the study. Leukocyte counts were performed at the time of admission (at the initiation of phototherapy), after 48 hours, and 96 hours of phototherapy.
Results: After 48-96 hours of phototherapy there was a statistically significant drop in total leukocyte count observed in all babies irrespective of locality, antenatal or perinatal history, birth weight, gestational age, mode of delivery and postnatal age ($P<0.05$).
Conclusions: Phototherapy (after 48-96 hours) causes decrease in leukocyte count in neonates with hyperbilirubinemia.

INTRODUCTION

Jaundice is the most common morbidity in first week of life, occurring in 60% of term and 80% of preterm newborns (Lancet 2008). Phototherapy is the most widely used form of therapy for newborn infants with hyperbilirubinemia in order to decrease the body burden of neurotoxic bilirubin (Porter and Dennis, 2002; Tan,1996; Lamola *et al* 1981). Phototherapy is highly effective and long term adverse biological effects of phototherapy are absent, minimal, or unrecognized. Neonates receiving phototherapy have increased insensible water loss, redistribution of blood flow, watery diarrhoea, irritability, rise in temperature, retinal damage, bronze baby syndrome, gonadal toxicity, impaired maternal-infant interaction, hypocalcaemia, riboflavin deficiency, DNA strand breakage, chromosomal mutations damage, and thrombocytopenia.

Effect of phototherapy on leukocyte count has not been conclusively reported as a complication in any of the standard pediatric literature. Phototherapy has a negative impact on numerous parts of the oxidant/ antioxidant defense system in newborn hyperbilirubinemic infants and exposes them to potent oxidative stress (Aycicek and Erel, 2007) It has also been studied that phototherapy causes DNA damage in peripheral mononuclear leukocytes in term infants (Aycicek *et al* 2008). Phototherapy can affect the synthesis and release of cytokines from the peripheral immune system (Jahanshahifard *et al*, 2012).

Exposure to ultraviolet (UV) radiation initiates a complex cascade of responses that affect the immune system. Various immune mediators such as interleukin IL-1, IL-6, IL-10 and tumor necrosis factor-α (TNF-α) are secreted by the immune system of skin to support the systemic immunologic response (Narbutt *et al*, 2005). Cytokines are hormone-like proteins that enable immune cells to communicate, and they play an integral role in the initiation, perpetuation and subsequent down regulation of the immune response (Mclnnes *et al* 2013). This immune response may alter the leukocyte count in neonates receiving phototherapy. In our study we observed the effect of phototherapy on leukocyte count, given to neonates with hyperbilirubinemia.

Corresponding author:* **Prabhakar N
[1]Department of Pediatrics, NSCB MCH Jabalpur, Madhya Pradesh, India

METHODS

A prospective study after ethical clearance from institutional ethical commettee was conducted in the Department of Pediatrics in Netaji Subhash Chandra Bose Medical College and Hospital, Jabalpur, Madhya Pradesh (India) between August 2009 and August 2010; in consecutively enrolled apparently healthy neonates, who developed indirect hyperbilirubinaemia and required phototherapy irrespective of gestational age and birth weight.

The indication of phototherapy was based on IAP-NNF guidelines 2006 on level II Neonatal care: American Academy of Pediatrics 2006[10]. Neonates having features suggestive of haemolysis, direct hyperbilirubinemia, sepsis, congenital infection associated with TORCH, severe congenital malformation, maternal diabetes, hypoxia, respiratory distress, exchnge transfusion, newborn of mothers with pre-eclampsia, steroid treatment or diabetes melitus were excluded from the study. Neonates who fulfilled the inclusion criteria after informed consent enrolled in the study and after detailed history, clinical examination and baseline investigation put on continuous phototherapy.

General information regarding age/sex, socioeconomic status (family income per month), gestational age and birth order were obtained from baby's mother/father/attender whoever was best available. Special information regarding baby's mode of delivery, birth weight, significant antenatal/perinatal history, significant past medical history of mother, drug history and significant family history were also recorded through interview and by analyzing documents available. Routine investigations of all these babies included hemoglobin estimation, RBC count, Hematocrit value, WBC count and platelet count were done by electronic cell counter (Impedance principle, light scattering, centrifugation and quantitative buffy coat analysis). Other than these investigations blood group of baby and mother, blood culture and antibiotic sensitivity, screening for G-6PD deficiency when required, coomb's test if needed were also done. The total, direct and indirect serum bilirubin level estimation of the baby was done on admission and every 24 hourly till the baby was on phototherapy. WBC counts were performed at the time of admission (at the initiation of phototherapy), after 48 hours, and 96 hours of phototherapy. Blood samples were collected as per the standard protocol a 2 ml blood sample in vials containing anticoagulant (EDTA). All these samples were immediately sent to central laboratory of department of pathology for analysis and reporting.

Conventional phototherapy systems consisted of six white fluorescent tubes (Philips TL 52/20W) placed 40 cm above the infant. Intensive phototherapy systems consisted of 12 white fluorescent tubes (Philips TL03) placed within 20 cm under and above the infant's front and back. The infants were placed naked, except for a diaper and eye patches(genital padding for males), in an incubator or cradle, or intensive phototherapy unit. The light energy of the phototherapy units was measured using a standard photometer (Light Meter VF, Minolta, Japan), conventional phototherapy units were 12-16 $\mu W/cm^2/nm$, and intensive phototherapy units were 30-34 $\mu W/cm^2/nm$. For bilirubin levels greater than 22 mg/dL, intensive phototherapy was applied; otherwise, lower than 22 mg/dL, randomized conventional or intensive phototherapy was applied.

Data analysis relating to effect of phototherapy on hematological indices- haemoglobin level, platelet count, WBC count and serum bilirubin were correlated with mode of birth (LSCS vs Vaginal delivery), birth weight (less than 2.5kg vs more than 2.5 kg) gestational age (preterm vs term), significant (negative vs positive) antenatal/perinatal history , locality (rural vs urban), income (less than 4830, 4380-6560, >6560) postnatal age of the baby in days (<1, 1-7, 7-14, >14) was done and statistical analysis conducted.

Sample size was calculated considering a significance of 0.05 and a statistical power of 90%. Descriptive statistical analysis was done and continuous variables were described as mean and standard deviation and categorical variables in number and percentage (%). Student's t test and at some places ANOVA test has been used to assess continuous variables for pair-matched samples with a confidence limit of 95%. Significance was assessed at a level of 5%. For categorical variables chi square test was used.

OBSERVATION AND RESULTS

Of the total 96 neonates under study, there were 67 males and 29 females. Sixty neonates were having weight < 2500 g, while 36 were ≥2500g. Onset of jaundice was maximum between in first week of postnatal age. Out of 96 there were 16 delivered via LSCS and 80 delivered via normal vaginal delivery (NVD). Similarly 57 were from rural area while 39 were from urban area. 56 had significant antenatal/perinatal history while 40 had no significant such history. 71 were preterm babies while 25 were full term babies. Neonates were also divided into 3 socioeconomic strata by their monthly family income that is <4380, 4380-6560, and >6560 were 70, 13, and 13 in numbers respectively. Babies were also divided according to postnatal age of presentation as <1 day, 2-7 days, 8-14 days, >14 days were 28, 56, 9 and 3 in numbers respectively.

After 48-96 hours of phototherapy all babies irrespective of locality, antenatal or perinatal history, birth weight, gestational age and postnatal age of newborn showed statistically significant drop in WBC count.

WBC count on 1st, 2nd and 3rd sample were compared according to locality as rural with mean and standard deviation as WBC1r (10.812±5.4638), WBC2r (8.884±2.9683), WBC3r (6.6±1.6971) and a significant drop in WBC count between 1st and 2nd sample($P<0.05$) and between 1st and 3rd sample ($p<0.05$) was observed and in babies from urban area WBC1u(11.003±5.2388), WBC2u (8.844±3.579), WBC3u (6.1±1.2728) and on comparison between 1st and 2nd sample ($P<0.05$) and 1st and 3rd sample ($P<0.05$) a significant drop was observed.(Table 1)

Table - 1 Correlation of WBC Count With Locality (Rural/Urban)

Locality		WBC 1 A	WBC 2 B	WBC 3 C	P A/B	P B/C	P A/C
Rural I	Mean	10.812	8.884	6.6	<0.05	>0.05	<0.05
	Standard deviation	5.4638	2.9683	1.6971			
	N	57	57	57			
Urban II	Mean	11.003	8.844	6.1	<0.05	>0.05	<0.05
	Standard deviation	5.2388	3.579	1.2728			
	N	39	39	39			
P I/II		>0.05	>0.05	>0.05			

WBC count on 1st, 2nd and 3rd sample were compared according to antenatal and perinatal history as if significant history present with mean and standard deviation as WBC1p (10.529±5.297), WBC2p (8.884±3.4713), WBC3p (6.667±1.1719) and a significant drop in WBC count between 1st and 2nd sample (P<0.05) and between 1st and 3rd sample (p<0.05) was observed and in babies with absence of such history WBC1a (11.395±5.4416), WBC2a (9.133±2.8536), WBC3a (5.4±1.2728) and on comparison between 1st and 2nd sample (P<0.05) and 1st and 3rd sample (P<0.05) a significant drop was observed.(Table 2)

TABLE - 2 Correlation of wbc count with present versus absent antenatal/perinatal history

Antenatal/perinatal history		WBC 1 A	WBC 2 B	WBC 3 C	P A/B	P B/C	P A/C
Present I	Mean	10.529	8.884	6.667	<0.05	<0.05	<0.05
	Standard deviation	5.297	3.4713	1.1719			
	N	40	40	6			
Absent II	Mean	11.395	9.133	5.4	<0.05	>0.05	<0.05
	Standard deviation	5.4416	2.8536	1.2728			
	N	56	56	4			
P I/II		>0.05	>0.05	>0.05			

Similarly WBC count on 1st, 2nd and 3rd sample were compared according to gestational age as if less than 38 weeks with mean and standard deviation as WBC1(9.899±4.8506), WBC2(8.442±2.9041), WBC3(7.867±2.318) and a significant drop in WBC count between 1st and 2nd sample (P<0.05) and between 1st and 3rd sample (p<0.05) was observed and in babies with 38-42 weeks as WBC1(13.704±5.7764), WBC2(10.544±3.5922), WBC3(7.8±1.2728) and on comparison between 1st and 2nd sample (P<0.05) and 1st and 3rd sample (P<0.05) a significant drop was observed.(Table 3)

Table - 3 Correlation of WBC count with gestational age(preterm/term)

Gestational age		WBC 1 A	WBC 2 B	WBC 3 C	P A/B	P B/C	P A/C
Preterm (<38 WK) I	Mean	9.899	8.442	7.867	<0.05	>0.05	<0.05
	Standard deviation	4.8506	2.9041	2.318			
	N	71	71	71			
Term (38-42 WK) II	Mean	13.704	10.544	7.8	<0.05	>0.05	<0.05
	Standard deviation	5.7764	3.5922	1.2728			
	N	25	25	25			
P I/II		>0.05	<0.05	>0.05			

Similarly WBC count on 1st, 2nd and 3rd sample were compared according to birth weight as if less than 2.5 kg with mean and standard deviation as WBC1(9.775±4.9486), WBC2(8.303±3.0209), WBC3(7.1±1.2728) and a significant drop in WBC count between 1st and 2nd sample (P<0.05) and between 1st and 3rd sample (p<0.05) was observed and in babies with more than 2.5 kg as WBC1(12.747±5.5342), WBC2(10.133±3.2423), WBC3(6.6±1.6971) and on comparison between 1st and 2nd sample (P<0.05) and 1st and 3rd sample (P<0.05) a significant drop was observed. (Table 4)

Table - 4 Correlation of Wbc Count With Birth Weight (<2.5KG/≥2.5KG)

Birth Weight		WBC 1 A	WBC 2 B	WBC 3 C	P A/B	P B/C	P A/C
<2.5 KG I	mean	9.775	8.303	7.1	<0.05	>0.05	<0.05
	standard deviation	4.9486	3.0209	1.2728			
	N	60	60	60			
≥2.5 KG II	mean	12.747	10.133	6.6	<0.05	<0.05	<0.05
	standard deviation	5.5342	3.2423	1.6971			
	N	36	36	36			
P I/II		<0.05	<0.05	>0.05			

Also we studied WBC count on 1st, 2nd and 3rd sample with reference to postnatal day of admission if less than 1 day with mean and standard deviation as WBC1(10.271±3.8809), WBC2 (8.029±2.4303), WBC3(10±1.230) and a significant drop in WBC count between 1st and 2nd sample (P<0.05) and between 1st and 3rd sample (p<0.05) was observed and in babies admitted between 2-7 days as WBC1(10.795±4.6137), WBC2(9.009±2.8871), WBC3(6.8±1.9799) and on comparison between 1st and 2nd sample (P<0.05) and 1st and 3rd sample (P<0.05) a significant drop was observed. Similarly those presented with hyperbilirubinemia between 8-14 days showed WBC1 (11.289±8.4458), WBC2 (8.656±5.1808), WBC3 (7.8±1.9799) and on comparison between 1st and 2nd sample (P<0.05) and 1st and 3rd sample (P<0.05) a significant drop was observed and babies presented after 14 days of birth with WBC1 (17.233±14.7331), WBC2 (8.656±5.1808), WBC3 (5.8±1.6799) and on comparison between 1st and 2nd sample (P<0.05) and 1st and 3rd sample (P<0.05) a significant drop was observed. (Table 5)

Table - 5 Correlation of wbc count with postnatal age of admission

Mode of Delivery		WBC 1 A	WBC 2 B	WBC 3 C	P A/B	P B/C	P A/C
<1 DAY I	Mean	10.271	8.029	10.001	<0.05	<0.05	>0.05
	Standard Deviation	3.8809	2.4303	1.230			
	N	28	28	28			
2-7 DAYS II	Mean	10.795	9.009	6.8	<0.05	>0.05	<0.05
	Standard Deviation	4.6137	2.8871	1.9799			
	N	56	56	56			
8-14 DAYS III	Mean	11.289	8.656	7.8	<0.05	>0.05	<0.05
	Standard Deviation	8.4458	5.1808	1.9799			
	N	9	9	9			
>14 DAYS IV	Mean	17.233	8.656	5.8	<0.05	<0.05	<0.05
	Standard Deviation	14.7331	5.1808	1.6799			
	N	3	3	3			

Similarly WBC count on 1st, 2nd and 3rd sample were compared according to mode of delivery as if born by LSCS with mean and standard deviation as WBC1(9.688±3.3704), WBC2(7.750±2.1213), WBC3(6.234±1.765) and a significant drop in WBC count between 1st and 2nd sample (P<0.05) and between 1st and 3rd sample (p<0.05) was observed and in babies born by normal vaginal delivery (NVD) as WBC1 (11.130±5.6450), WBC2 (9.238±3.3465), WBC3 (7.850±1.8930) and on comparison between 1st and 2nd

sample (P<0.05) and 1st and 3rd sample (P<0.05) a significant drop was observed. (Table 6)

Table - 6 Correlation of wbc count with mode of delivery (LSCS/NVD)

Mode of Delivery		WBC 1 A	WBC 2 B	WBC 3 C	P A/B	P B/C	P A/C
LSCS I	Mean	9.688	7.750	6.234	<0.05	>0.05	<0.05
	Standard Deviation	3.3704	2.1213	1.765			
	N	16	16	6			
NVD II	Mean	11.130	9.238	7.850	<0.05	>0.05	<0.05
	Standard Deviation	5.6450	3.3465	1.8930			
	N	80	80	73			
P I/II		>0.05	<0.05	<0.05			

DISCUSSION

Phototherapy is widely accepted as a relatively safe and effective method for treatment of neonatal hyperbilirubinemia. Wide clinical experience suggests that long term adverse biological effects of phototherapy are absent, minimal or unrecognized. However, those using phototherapy should remain alert to these possibilities and avoid any unnecessary use because untoward effects on DNA have been demonstrated in vitro (Tan, 1996;Barbara *et al* Nelson 20th edition; Brennan *et al* 2002).

Also it has been studied that phototherapy affects- the level of tumor necrosis factor (TNF-α), interleukin (IL)- 1b, IL-6, IL-8 cytokines expressed from keratinocytes and expressed on some lymphocyte subsets, used in the prevention or treatment of neonatal hyperbilirubinemia. After 72 hours of exposure of phototherapy it was observed that level of serum TNF-α, IL-1b, IL-8 were significantly increased, while serum IL-6 level were not significantly changed. Lymphocytes, lymphocyte subsets and white blood cell levels were similar in the study and control groups. Only the percentage of CD3+ lymphocyte subset was significantly lower in newborns at 72 hour of exposure to phototherapy. All other lymphocyte subsets were decreased by the exposure to phototherapy, and this change was not statistically significant. The results demonstrate that in addition to the well-known positive effect of phototherapy on the neonatal serum bilirubin level, this therapy can affect the function of the immune system in newborn via alteration in cytokine production (Kurt *et al* 2009). In another study whole T-lymphocytes were not affected after 48 hours of phototherapy but CD4+ T-lymphocytes were significantly increased after 8 hours of phototherapy (Karabayir *et al* 2011). In a study in newborns Pracianoy *et al* found no statistical significant difference in TNF-α concentrations before and after 24 hours of phototherapy (Procianoy *et al* 2010).

A few studies dealing with the effect of UV on immune system showed the inhibition of the expansion of effectors CD4+ and CD8+ T-cells in skin draining lymph nodes (Rana *et al*, 2008). In another study on adults, a significant decrease in both B and T subgroups after exposure to UV light has been reported (Erduran *et al*). Furthermore, UV B treatment suppresses the type axis as defined by IL-12, IFN-γ and IL-8, and can selectively reduce pro-inflammatory cytokine production by individual T cells (Schwartz, 2002; Walter *et al*, 2003). In another study It was reported that phototherapy caused to increase IL-2, IL-10 production and to decrease IL-1b secretion (Sirota *et al* 1999). In a study evaluating the lymphoproliferative response and immunoglobulins, phototherapy was shown to inhibit lymphoproliferative response (Rubaltelli *et al*, 1977). In a study on adults, low dose UVB light is suggested to cause a decrease in CD4+ and CD8+ cells after phototherapy, but at non significant rates.

At present no standard literature is present for the effect of phototherapy on leukocytes in neonates with hyperbilirubinemia. Studies done previously were either inconclusive or with non-homogenous results. Phototherapy exerts action on element of peripheral part of immune system, as this part is readily accessible to photons but photons have effect on deeper part of the immune system also (Nishigori *et al* 1996; Clement *et al*, 1996). These can induce breaking of DNA strands and sister chromatid mutation (Bradley *et al* 1978; Sideris, 1981). Volkom *et al* hypothesized that phototherapy generate free oxygen radicals and may cause DNA damage in nucleated cells (Volkman *et al*, 2004). Also pro-inflammatory cytokines are down regulated. All these effects may combine to affect WBC count (Schwartz, 2002; Walter *et al*, 2003). In our study, we found a significant decrease in WBC count after 48-96 hours of phototherapy in all babies irrespective of locality, mode of delivery, antenatal or perinatal history, birth weight, gestational age and postnatal age of newborn.

In contrast to the present study Sakha *et al* showed that during phototherapy there is increase in WBC count which could be due to physiological rise that occurs day by day. They also reported that phototherapy stimulate marginated WBCs to enter the circulation leading to apparent rise in WBC count (Sakha and Soltani 2006). In another study also WBC count was increased by exposure to phototherapy and they commented that as neonates were healthy except being hyperbilirubinemic, increase in WBC may be due to stress of admission or beginning of infection (Jahanshahifard *et al* 2012).

In our study we found a significant decrease in leukocyte count after receiving phototherapy in neonates with hyperbilirubinemia. Though the neonates didn't developed leucopenia but this study helps the practitioner to be aware of this association and avoid using some drugs which may cause leucopenia and also avoiding the factors which may cause leucopenia otherwise neonate may become immunodeficient and prone for the infection. Also this effect was transient and practitioners should be aware of it and shouldn't ask for unnecessary investigations.

The findings of the present study calls for larger longitudinal studies. It also needs studies to be conducted about DNA damage and other harmful delayed consequences due to phototherapy in larger number of babies. It also needs to correlate delayed effect of natural sunlight phototherapy versus hospital based phototherapy.

What Is Already Known

Phototherapy causes free radical production, DNA damage in WBCs and alters the level of cytokines and may alter the WBC count.

What This Study Adds

Phototherapy in all babies irrespective of locality, mode of delivery, antenatal or perinatal history, birth weight, gestational age and postnatal age of newborn causes significant decrease in WBC count.

References

1. Young Infants Clinical Signs Study Group. Clinical signs that predict severe illness in children under age 2 months: a multicentre study. Lancet 2008; 371:135-42.
2. Porter ML, Dennis BL, Hyperbilirubinemia in the term newborn. Am Fam Physician.2002; 65; 599-606.
3. Tan KL. Phototherapy for neonatal jaundice. Acta Paediatr. 1996; 85:277-9.
4. Lamola AA, Blumberg WE, McClead R, Fanaroff A. Photoisomerized bilirubinin blood from infant receiving phototherapy. Proc Natl Acad Sci U S A. 1981; 78:1882-6.
5. Aycicek A, Erel O. Total oxidant/antioxidant status in jaundiced newborns before and after phototherapy. J Pediatr (Rio J). 2007; 83:319-22.
6. Aycicek A, Kocyigit A, Erel O, Senturk H. Phototherapy causes DNA damage in peripheral mononuclear leukocytes in term infants. J Pediatr (Rio J); 2008; 84(2):141-146.
7. Jahanshahifard S, Ahmadpour-Kacho M, Pasha YZ. Effects of phototherapy on cytokines levels and white blood cells in term neonate with hyperbilirubinemia. J Clin Neonatology 2012; 1:139-142.
8. Narbutt J, Lesiak A, Skibinska M, *et al*. Repeated dose of UVR cause minor alteration in cytokine serum levels in humans. Mediators Inflamm 2005; 5:298-303.
9. Mclnnes IB, Furst DE, Romain PL. Role of cytokines in rheumatic diseases; Uptodate; 2013:7997.
10. American Academy of Pediatrics Subcommittee on Hyperbilirubinemia. Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. Pediatrics 2004; 114:297–316. Erratum in: Pediatrics 2004; 114:1138.
11. Barbara JS, Robert MK. Jaundice and hyperbilirubinemia in yhe newborn. In: Behrman RE, Kliegman RM, Jenson HB, editors. Nelson Textbook of Pediatrics. 20th ed. Philadelphia. PA: Kennedy JF; 871-876.
12. Kurt A, Aygun AD, Kurt AN, Godekmerdan A, Akarsu S, Yilmaz E. Use of phototherapy for neonatal hyperbilirubinemia affects cytokine production and lymphocyte subsets. Neonatology 2009; 95(3):262-6.
13. Karabayir N, Yilmaz S, Adal SE, Aydogmus C. The effect of phototherapy on the lymphocyte subsets in Newborn. Turkiye Klinikleri *Journal of medical sciences* 2011; 31(5):1245-1249. DOI: 10.5336/medsci. 2011-23229.
14. Rana S, Byrne SN, MacDonald LJ, Chan CY, Halliday GM. Ultraviolet B suppresses immunity by inhibiting effector and memory T cells. Am J Pathol 2008; 172(4):993-1004.
15. Erduran E, Arslan MK, Alperen A, Tekelioglu Y. In vitro investigation of the effect of ultraviolet- C light on lymphocytes. Turk Hematoncology Derg;7(1):30-2.
16. Schwartz T. Photoimmunosuppression. Photodermatol Photoimmunol Photomed 2002; 18(3)141-5.
17. Walter IB, Ozawa M, Cardinale I, Gilleaudeau P, Trepicchio WL, Bliss J, *et al*. Narrow band (312nm) UV-B suppresses interferon gamma and interleukin IL-12 and IL-4 transcripts: differential regulation of cytokines at the single cell level. Arch Dermatol 2003; 139(2):155-61.
18. Sirota L, Straussberg R, Gurary N, Aloni D, Bessler H. Phototherapy for neonatal hyperbilirubinemia affects cytokine production by peripheral blood mononuclear cells. Eur J Pediatr 1999; 158(11):910-3.
19. Rubaltelli FF, Piovesan AL, Semenzato G, Barbato A, Ongaro G. Immune competence assessment in hyperbilirubinemic newborns before and after phototherapy. Helv Paediatr Acta 1977; 32(2):129-33.
20. Brennan ML, Wu W, Fu X, Shen Z, Song W, Frost H, *et al*. A tale of two controversies: defining both the role of peroxidases in nitrotyrosine formation in vivo using eosinophil peroxidase and myeloperoxidase deficient mice, and the nature of peroxidase-generated reactive nitrogen species. J Biol Chem. 2002; 277:17415-27.
21. Nishigori C, Yarosh DB, Ullrich SE, Vink AA, Bucana CD, Roza L, *et al*. Evidence that DNA damage triggers interleukin 10 cytokine production in UV-irradiated murine keratinocytes. Proc Natl Acad Sci USA.1996; 93:10354–9.
22. Clement LT. Cellular interactions in the human immune response. In: Stiehm ER, editor. Immunologic Disorders in Infants & Children. 4th ed. Philadelphia: W.B. Sanders; 1996. pp. 83–4.
23. Bradley MO, Erickson LC, Kohn KW. Nonenzymatic DNA strand breaks induced in mammalian cells by fluorescent light. Biochim Biophys Acta. 1978; 520:11–20.
24. Sideris EG, Papageorgiou GC, Charalampous SC, Vitsa EM. A spectrum response study on single strand DNA breaks, sister chromatid exchanges and lethality induced by phototherapy light. Pediatr Res.1981; 15:1019–23.
25. Volkom, Izakovic M, Mazur M, Rhodes CJ, Telser J. Role of oxygen radicals in DNA damage and cancer incidence. Mol Cell Biochem. 2004; 266:37-56.
26. Sakha K, Sultani H. Effect of phototherapy on platelet and leukocyte count in term infants. Med Journal of Tabriz University of Medical Sciences.2006,28(3),14-8.
27. Jahanshahifard S, Ahmadpour-Kacho M, Pasha YZ. Effect of phototherapy on cytokines' levels and white blood cells in term neonate with hyperbilirubinemia. J Clin Neonatol. 2012Jul-Sept; 1(3):139-142.
28. Procianoy RS, Silveira RC, Fonseca LT, *et al.* The influence of phototherapy on serum cytokine concentrations in newborn infants. Am J Perinatol 2010; 27:375-379?

TSSN 0976-3031