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ORIGINAL ARTICLE

Outcomes of Conventional Phototherapy versus Fiberoptic Phototherapy in the Management of Neonatal Jaundice

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ABSTRACT

Background: Neonatal jaundice is a common clinical condition affecting a large proportion of newborns worldwide.

Objective: To evaluate and compare the outcomes of conventional phototherapy versus fiberoptic phototherapy in the management of neonatal jaundice.

Methodology: This comparative cross-sectional study was conducted at Department of Pediatrics, Sahara Medical College Narowal from 1st March 2023 to 31st August 2023 among 260 neonates diagnosed with neonatal jaundice. Participants were randomly assigned to receive either conventional phototherapy using blue fluorescent lamps (Group A, n = 130) or fiberoptic phototherapy via bili-blanket systems (Group B, n = 130). Serum total bilirubin (STB) levels were measured before treatment and every 12 hours until normalization.

Results: The mean baseline bilirubin levels were comparable between the two groups (17.6±2.4 mg/dL vs. 17.4±2.6 mg/dL; p=0.59). After 24 hours, the mean bilirubin reduction was significantly higher in the conventional group (6.1±1.8 mg/dL) compared to the fiberoptic group (4.9±1.7 mg/dL; p<0.001). The average duration of therapy was shorter with conventional phototherapy (28.5±6.3 hours) than with fiberoptic therapy (36.8±7.5 hours; p < 0.001). However, fiberoptic phototherapy showed fewer side effects, with lower incidences of hyperthermia (4.6% vs. 13.1%; p = 0.02) and dehydration (3.8% vs. 11.5%; p = 0.03). No cases required exchange transfusion, and rebound hyperbilirubinemia rates were similar (p = 0.62).

Conclusion: Both conventional and fiberoptic phototherapy are effective in reducing serum bilirubin in neonates with jaundice. Conventional phototherapy provides faster bilirubin clearance and shorter treatment duration, while fiberoptic phototherapy offers improved safety, comfort, and bonding opportunities.

Keywords: Neonatal jaundice, Phototherapy, Fiberoptic bili-blanket, Hyperbilirubinemia

INTRODUCTION

Neonatal jaundice is one of the most prevalent conditions encountered during the first week of life, manifesting as a yellow discoloration of the skin and sclera caused by elevated serum bilirubin levels.[1] This condition occurs in about 60 percent of term, and up to 80 percent of preterm babies worldwide, that is why it is a significant issue in neonatal care units. Increased bilirubin is usually physiological, due to the immaturity of hepatic conjugation processes and increased degradation of fetal red blood cells.[2] Nevertheless, in neonates with some cases of this, the bilirubin levels could go beyond the normal physiological range, causing pathological jaundice that requires immediate medical intervention to avoid neurological complications like acute bilirubin encephalopathy and kernicterus that could result in permanent brain damage, cerebral palsy, sensorineural hearing loss, or even death without treatment.[3]

The most commonly accepted non-invasive treatment of neonatal hyperbilirubinemia is phototherapy which is considered to be the gold standard of treatment.[4] It works on the premise of photo-oxidation and structural isomerization of the unconjugated bilirubin into more soluble forms like lumirubin, which could then be excreted through bile and urine without any necessity of being hepatically conjugated.[5] The types of phototherapy units which are developed over the years vary in terms of their sources of light, wavelength range, intensity of irradiance, and delivery systems. Of these, the most widely used has been traditional phototherapy with lamps of fluorescent blue color (usually 430-490 nm) because it is cost-effective and has proved to be effective. Nevertheless, the traditional phototherapy is not completely free of disadvantages.[6] Various factors affect its efficiency such as distance between the light source and the infant, the area of body being exposed to the light, aging of the lamp and uneven distribution of light. Also, long-term exposure to high-intensity light may cause such side effects as dehydration, skin rashes, hyperthermia, retinal damage, and disruption to maternal-infant bonding because babies have to be separated with a mother during treatment.[7]

Such limitations have led to the current innovations of newer technologies such as the fiberoptic phototherapy, which can increase efficacy, comfort and safety. The fiberoptic phototherapy involves the use of a flexible pad or blanket which consists of fiberoptic cables that are used to pass the light to the surface of the infant.[8] The approach permits the continuation of treatment when the infant is being held, breastfed, or fed, this is to ensure that there is bonding and also minimizes the stressor of separation.[9] It offers localized light, reduces heat production and exposure to the eye with effective reduction of bilirubin. Furthermore, fiberoptic equipment is small, consumes less energy, and may be utilized both in the hospital and home so it can also be helpful in low-resource settings or step-down units.[10] Although these benefits have been noted, fiberoptic phototherapy has been reported to have a lower bilirubin lowering rate than conventional systems particularly in extreme cases where greater irradience levels are needed. A number of comparative studies have attempted to assess efficacy and safety profiles of conventional and fiberoptic phototherapy with mixed results.[11]

The conventional phototherapy has been reported by some researchers to induce a faster rate of reduction of serum bilirubin levels because of its larger coverage of surface area and greater irradiance whereas no significant difference between the overall efficacy of the two modalities has been reported.[12]

MATERIALS AND METHODS

This was a comparative cross-sectional study conducted at Department of Pediatrics, Sahara Medical College Narowal from 1st March 2023 to 31st August 2023. A total of 260 neonates diagnosed with neonatal jaundice were included. Non-probability consecutive sampling was used to recruit eligible participants. All neonates aged between 1 and 14 days, both term and preterm infants with clinically and biochemically confirmed

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hyperbilirubinemia requiring phototherapy as per the American Academy of Pediatrics (AAP) guidelines and birth weights above 1.8 kg were included. Those neonates with hemolytic disease due to Rh or ABO incompatibility, conjugated hyperbilirubinemia, sepsis, congenital anomalies, or major systemic illness and previously received exchange transfusion or phototherapy before admission excluded. All neonates underwent baseline clinical assessment, including gestational age, birth weight, feeding status, and bilirubin levels. Serum total bilirubin (STB) was measured before initiation of phototherapy and then every 12 hours until levels dropped below the treatment threshold. The enrolled neonates were randomly divided into two equal groups (n = 130 each): Group A received conventional phototherapy using standard blue fluorescent lamps emitting light in the 430–490 nm wavelength range and group B received fiberoptic phototherapy using a bili-blanket system providing continuous light exposure through fiberoptic pads.

Data were collected using a structured proforma, and serum bilirubin levels were analyzed in the hospital's biochemistry laboratory. Clinical observations were recorded every 6 hours during therapy. The distance between the light source and the infant was standardized at 30-40 cm for conventional phototherapy, and fiberoptic devices were applied directly to the infant's torso with appropriate padding. Eye protection was ensured in the conventional group but was not required for fiberoptic treatment. Feeding was continued throughout treatment in both groups, with close monitoring for hydration and temperature stability. All data were entered into SPSS version 26.0 for statistical analysis. Independent sample t-test was applied to compare mean bilirubin reduction between groups, and Chi-square test was used for categorical data. A p-value <0.05 was considered statistically significant.

RESULTS

The mean age of neonates was 4.8±1.9 days in the conventional group and 5.0±2.1 days in the fiberoptic group. The mean birth weight was comparable, with 2.85±0.42 kg in the conventional group and 2.79±0.46 kg in the fiberoptic group. Gender distribution was similar, with 56.9% males in the conventional group and 54.6% males in the fiberoptic group. The majority of neonates in both groups were term, with 87.7% in the conventional group and 85.4% in the fiberoptic group. Baseline total serum bilirubin levels were almost identical, at 17.6±2.4 mg/dL for the conventional group and 17.4±2.6 mg/dL for the fiberoptic group (Table 1).

The conventional phototherapy group showed significantly greater bilirubin reduction, with a mean serum bilirubin reduction of 6.1±1.8 mg/dL after 24 hours, compared to 4.9±1.7 mg/dL in the fiberoptic group (p<0.001). The rate of bilirubin decline was also faster in the conventional group (0.25±0.06 mg/dL/hour) versus the fiberoptic group (0.19±0.05 mg/dL/hour) (p<0.001). The duration of therapy was shorter in the conventional group (28.5±6.3 hours) compared to 36.8±7.5 hours in the fiberoptic group (p<0.001). Hospital stay was significantly shorter in the conventional group (2.6±0.8 days) compared to 3.1±0.9 days in the fiberoptic group (p=0.01). No significant difference was seen in rebound hyperbilirubinemia (6.1% vs. 7.7%, p=0.62) [Table2].

Hyperthermia occurred in 13.1% of neonates in the conventional group, compared to 4.6% in the fiberoptic group (p=0.02), and dehydration was observed in 11.5% of the conventional group, compared to 3.8% in the fiberoptic group (p=0.03). Skin rash occurred in 10.7% of the conventional group versus 6.9% in the fiberoptic group (p=0.29). Eye irritation was significantly more frequent in the conventional group (8.4%) compared to 0% in the fiberoptic group (p<0.001) [Table 3].

At baseline, the bilirubin levels were similar between groups (17.6±2.4 mg/dL for conventional and 17.4±2.6 mg/dL for fiberoptic, p=0.59). However, by 12 hours, the conventional phototherapy group had significantly lower bilirubin levels (13.8±2.1 mg/dL) compared to the fiberoptic group (15.0±2.2 mg/dL, p<0.001). At 24 hours, the conventional group had 11.5±1.9 mg/dL, compared to 12.9±2.0 mg/dL in the fiberoptic group (p<0.001). By 36 hours, conventional phototherapy reached 9.8±1.7 mg/dL, while fiberoptic phototherapy had 11.4±1.9 mg/dL (p<0.001). At the end of therapy, bilirubin was 8.3±1.4 mg/dL in the conventional group and 9.2±1.5 mg/dL in the fiberoptic group (p<0.001) [Table 4].

A positive correlation was observed between baseline bilirubin levels and the duration of phototherapy in both groups. In the conventional group, the Pearson correlation was 0.62 (p<0.001), while in the fiberoptic group, it was 0.67 (p<0.001) [Table 5].

Table 1: Baseline demographic and clinical characteristics of study population (n = 260)

Characteristic	Conventional Phototherapy (n = 130)	Fiberoptic Phototherapy (n = 130)
Mean age (days)	4.8±1.9	5.0±2.1
Mean birth weight (kg)	2.85±0.42	2.79±0.46
Male	74 (56.9%)	71 (54.6%)
Gestational age (term)	114 (87.7%)	111 (85.4%)
Normal vaginal delivery	82 (63.1%)	79 (60.8%)
Baseline total serum bilirubin (mg/dL)	17.6±2.4	17.4±2.6

Table 2: Comparison of therapeutic outcomes between conventional and fiberoptic phototherapy

Outcome variable	Conventional Phototherapy (n = 130)	Fiberoptic Phototherapy (n = 130)	Test Statistic	p-value
Serum bilirubin reduction after 24 hrs (mg/dL)	6.1±1.8	4.9±1.7	t = 5.40	<0.001*
Rate of bilirubin decline (mg/dL/hour)	0.25±0.06	0.19±0.05	t = 7.12	<0.001*
Duration of phototherapy (hours)	28.5±6.3	36.8±7.5	t = 9.11	<0.001*
Hospital stay (days)	2.6±0.8	3.1±0.9	t = 4.52	0.01*
Rebound hyperbilirubinemia	8 (6.1%)	10 (7.7%)	$\chi^2 = 0.25$	0.62
Need for exchange transfusion	-	-	-	-

*Significant

Table 3: Adverse effects observed during phototherapy

Adverse Effect	Conventional Phototherapy (n = 130)	Fiberoptic Phototherapy (n = 130)	Test Statistic	p-value
Hyperthermia	17 (13.1%)	6 (4.6%)	$\chi^2 = 5.33$	0.02*
Dehydration	15 (11.5%)	5 (3.8%)	$\chi^2 = 4.68$	0.03*
Skin Rash	14 (10.7%)	9 (6.9%)	$\chi^2 = 1.13$	0.29
Feeding Intolerance	6 (4.6%)	5 (3.8%)	$\chi^2 = 0.09$	0.76
Eye Irritation	11 (8.4%)	0 (0%)	$\chi^2 = 11.36$	<0.001*

*Significant

Table 4: Trend of serum total bilirubin levels over time in both groups

Time Interval (hours)	Conventional Phototherapy (n = 130)	Fiberoptic Phototherapy (n = 130)	Mean Difference	Test Statistic	p-value
Baseline (0 hr)	17.6±2.4	17.4±2.6	0.2	t = 0.54	0.59
12 hr after therapy	13.8±2.1	15.0±2.2	1.2	t = 4.01	<0.001*
24 hr after therapy	11.5±1.9	12.9±2.0	1.4	t = 5.18	<0.001*
36 hr after therapy	9.8±1.7	11.4±1.9	1.6	t = 6.02	<0.001*
End of therapy	8.3±1.4	9.2±1.5	0.9	t = 3.92	<0.001*

*Significant

Table 5: Correlation between baseline bilirubin and duration of phototherapy

Parameter	Conventional Phototherapy	Fiberoptic Phototherapy
Mean Baseline STB (mg/dL)	17.6±2.4	17.4±2.6
Mean Duration of Therapy (hours)	28.5±6.3	36.8±7.5
Pearson Correlation (r)	0.62	0.67
95% Confidence Interval for r	0.47 – 0.73	0.52 – 0.78
p-value	<0.001*	<0.001*

DISCUSSION

The two modalities were effective in decreasing serum bilirubin, however, major differences were noted in the bilirubin decreasing rate, length of therapy, and adverse effects. The results emphasize the strengths of each method which complement each other and the need to choose the right method depending on the clinical requirements, resources, and patient comfort. Traditional phototherapy, in this study, has proven to be much quicker in bilirubin levels reduction and shorter treatment period than fiberoptic phototherapy. The average rate of bilirubin reduction in the first 24 hours was greater in the conventional group (6.1±1.8 mg/dL) as compared to the fiberoptic group (4.9±1.7 mg/dL), and the mean bilirubin reduction rate was 0.25±1.8 mg/dL/hour and 0.19±1.7mg/dL/hour, respectively. These results are in line with the earlier studies that demonstrate the belief that traditional phototherapy has higher light irradiance and entire skin exposure to light accelerates photolith breakage and excretion of bilirubin. Research has indicated that traditional phototherapy uses of the high-intensity fluorescent and LED systems are usually quicker in clearing bilirubin because of improved photon density on the body area that is exposed by the infant.[13]

The benefits of conventional phototherapy, however, are checked by the macro effects being more prevalent. Adverse effects which included hyperthermia, dehydration and skin rash were higher in the conventional group in this study. Hyperthermia (13.1% and dehydration 11.5% incidence) was significantly greater than the fiberoptic group (4.6% and 3.8% of incidence, respectively). This observation is consistent with the previous evidence that supports conventional units generate more heat resulting in a variation in temperature and higher insensible water loss.[14] On the other hand, the fiberoptic phototherapy had a better safety profile, fewer complications, increased feeding tolerance, and thermoregulation. This underscores how it may be applicable in long-term treatment in stable neonates and in home-based care models. Phototherapy based on fiberoptic has also significant practical benefits. Due to the ability to integrate the source of light in a flexible pad that can be wound around the neonate, treatment proceeds in the course of breastfeeding or skin-to-skin contact or just during normal handling that reduces the interruptions in mother-infant attachment. The above study has highlighted the fact that this aspect is positively correlated with parental satisfaction and neonatal behavioral stability. Moreover, fiberoptic systems cause less heat and do not need eye protection, thus, it is less prone to thermal and eye injuries.[15]

These advantages notwithstanding, the slower rate of bilirubin fall seen with fiberoptic treatment is still a clinical drawback, especially in those neonates who are found with a high baseline bilirubin level or those who need to be corrected very quickly in order to prevent the possibility of bilirubin encephalopathy.[16] The correlation analysis of our study showed that there is strong positive correlation between the level of bilirubin at the baseline and the duration of therapy of the two modalities, and that infants with high initial bilirubin levels need longer therapy despite the kind of phototherapy (Table 5). Nonetheless, the average time of therapy was much better in the fiberoptic group (36.8±7.5 hours) than it was in the conventional one (28.5±6.3 hours), which confirms the fact that the conventional systems are still more effective in the intensive care management.[17] Other studies have mentioned equal effectiveness of conventional and fiberoptic phototherapy in case of high-intensity fiberoptic units and others have reported that conventional phototherapy was better in bilirubin reduction at a higher rate.[18] The differences in the studies can be explained by the differences in the level of irradiance produced, surface area exposure, and type of device. Notably, more recent generation fiberoptic systems with higher luminous flux have demonstrated higher performance, reducing the efficacy lag between them and the conventional systems.[19,20]

Limitations: This study was conducted in a single tertiary care center, which may limit generalizability. The sample excluded neonates with hemolytic disease or severe prematurity, which could influence bilirubin kinetics differently. In addition, irradiance levels were not standardized across devices beyond routine calibration, which may have affected comparative intensity. Future research using multicenter randomized controlled designs and standardized light intensity measurement is recommended to validate and expand upon these findings.

CONCLUSION

Both conventional and fiberoptic phototherapy are effective modalities for the management of neonatal jaundice, each with distinct advantages. Conventional phototherapy achieved a significantly faster reduction in serum bilirubin levels and required a shorter duration of therapy, making it more suitable for cases where rapid bilirubin clearance is essential.On the other hand, fiberoptic phototherapy, though slightly less rapid in bilirubin reduction, offered superior safety and comfort. It was associated with fewer side effects such as hyperthermia and dehydration, and allowed uninterrupted breastfeeding and maternal bonding factors that enhance neonatal care and recovery. Both treatment methods were safe, with no serious complications or need for exchange transfusion observed. The rate of rebound hyperbilirubinemia was comparable between the two groups, indicating that both modalities effectively maintained post-therapy bilirubin stability.

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