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Study of Auto-Inflating and Deflating Air Bed for Phototherapy Treatment of Infants

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ABSTRACT

This document provides an itemized investigation of the Phototherapy Air bed designed and curated to maximize the comfort level of phototherapy treatment of new born babies. Phototherapy bed is normally hard for infants and opaque, which restrict the ultra violet light from floor side to hit the babies back side. Thus doesn't give comfort to the babies which causes them unrest during the treatment and decreases the efficiency of the breakdown of bilirubin by bili-lights and thus results in bad or inefficient treatment. Beds had been designed like gel-pads and bubble wrap to give them comfort and increase the exposure of lights on neonatal but hadn't been that much successful due to their difficulty in application. Thus we had designed a very comfortable and easily equitable air bed which smoothly changes the pressure points of babies while they lay on it and gives them maximum comfort like a home bed which eliminates their random motion on the bed surface and also enhance the body surface area to exposure of Ultra- Violet Rays which maximizes efficiency of neonatal intensive care unit (NICU) and eases treatment of neonatal jaundice.

Keywords : Neonatal Jaundice, Phototherapy, Neonatal Phototherapy, Phototherapy Beds, Neonatal Intensive Care unit (NICU)

I. INTRODUCTION

Phototherapy is a type of medical treatment that involves exposure to fluorescent light bulbs or other sources like halogen lights, lightweight emitting diodes to treat jaundice in infants. It's sometimes used to treat new born jaundice by lowering the bilirubin levels in baby's blood through a process called photo-oxidation.

Photo-oxidation adds oxygen to the bilirubin so it dissolves easily in water and makes it easier for baby's liver to interrupt down and takes away the bilirubin from their blood [4].

There are multiple types of phototherapy and therefore the kind, also because the technique employed by your doctor, will depend upon the condition you've got that's being treated. Phototherapy is additionally referred to as light therapy and heliotherapy.

Approximately 60% of term babies and 85% preterm babies will develop clinically apparent jaundice, which classically becomes visible on day 3, peaks days 5-7 and resolves by 14 days of age during a neonate and by 21 days within the premature baby.

Treatment with phototherapy is implemented so to stop neurotoxic effects of high serum unconjugated bilirubin. Phototherapy may be safe and effective method for decreasing or preventing the increase the serum unconjugated bilirubin levels and reduces the necessity for transfusion in infants. [1,3,5]

More than half of normal new born present with clinical jaundice sometime during the 1st week of life. About 3% of all hospital-born babies in India develop significant jaundice, with total serum bilirubin (TSB) levels quite 15 mg/dl. Majority of them have unconjugated hyper bilirubinemia and are otherwise healthy. [5]

They need to be monitored very accurately because bilirubin is potentially toxic to the central system a nervosum and may cause bilirubin encephalopathy and subsequently kernicterus, with devastating, permanent neurodevelopmental handicaps [6]. Fortunately, current interventions make such severe sequelae rare [5].

Phototherapy is an effective method for treating neonatal hyperbilirubinemia because it is easily available and devoid of complications of double volume exchange transfusions.

The efficacy of phototherapy depends on the irradiance, the wavelength of the light used and the surface area exposed. Compact fluorescent lamp (CFL) and light-emitting diode (LED) phototherapy units are available in the market for the last few years while the traditional phototherapy machines using special blue lights have been available for many decades.Various tests have been conducted to study the efficiency of various phototherapy units used in Neonatal Intensive Care Unit (NICU) [5].

It is observed that the researchers conduct various study to dig information about which Phototherapy provides best results for ultra violet rays and absorption of oxygen to the bilirubin so it dissolves easily in water and makes it easier for baby's and takes away the bilirubin from their blood. And result shows that there is Ensuring effective flux, adequate feeding, and constant monitoring, all the 3 phototherapy devices could be used to treat hyperbilirubinemia without significant adverse effects [5].

A. **Definition of Terms:**

1) ***Jaundice***: The yellow appearance of the skin that occurs with the deposition of bilirubin in the dermal and subcutaneous tissues is termed as jaundice [4].
2) ***Bilirubin:*** The yellow pigment of bile; an elusive body part, formed majorly by the breakdown of haemoglobin in red blood cells at the end of their normal life-span. Neonate's bilirubin production rate is twice as that of adults and their clearance of bilirubin is almost halved, hence the importance of monitoring levels and detecting jaundice in this early post-natal period increases [4].
3) ***Bilirubinaemia:*** The presence of bilirubin in the blood in any amount [4].
4) ***Hyperbilirubinemia:*** The presence of more and more bilirubin in the blood other than needed [4].

B. **Types of Neonatal Hyperbilirubinemia:**

There are different types of neonatal hyperbilirubinemia the most common is

Unconjugated, less prominent in infants is Conjugated, Serum Bilirubin (SBR), Total serum bilirubin levels (TSB), Breast milk jaundice During phototherapy neonates require on-going monitoring of adequacy of hydration (urine output) and nutrition (weight gain) temperature clinical improvement in jaundice.

C. **Phototherapy**

Phototherapy has been used to treat medical conditions dated back to 3,500 years ago when egyptians and indians used sunlight to treat skin conditions like vitiligo and leucoderma.

Modern phototherapy, using artificial light sources came into work by Niels Ryberg Finsen.Regarded as the founder of modern phototherapy, he treated a skin condition called lupus vulgaris with sunlight and ultraviolet radiation. From then on, the usage of phototherapy in medical fields started growing, techniques were refined and developed, and it eventually gained widespread acceptance.

Phototherapy has been used for more than six decades to treat hyper-bilirubinemia and jaundice, the phototherapy is applied to reduce the baby's bilirubin levels 7. Bilirubin absorbs light, which results in the breakdown of bilirubin to substances that the baby's body can process and excrete. [1]

Phototherapy for treating hyper-bilirubinemia and jaundice is considered very safe medically. Whether there are few side effects of mild in nature such as diarrhoea, rashes, overheating, and water loss/dehydration. A treatment for jaundice where the skin is exposed to a light source which converts unconjugated bilirubin molecules into water soluble molecules that can be excreted by the urine or bowel pathways. Blue-green light is most effective for phototherapy as it penetrates the skin and is also absorbed by bilirubin to have the photochemical effect [1,4].

Phototherapy process is started when TSB/SBR is greater than the appropriate reference range for neonate's gestation period or weight and presence of risk factors. Neonates should be nursed naked apart from a diaper probably under phototherapy and will need to be nursed in an Isolated environment to maintain an appropriate neutral thermal environment. In severe cases, the nappy may need to be removed and a urine bag applied to maximise skin exposure which is eventually fruitful [4].

During Phototherapy following things to be noticed in aspect of NICU which are important for this study.

1) Positon phototherapy units no more than 25cm from the patient. neo BLUE LED phototherapy unit are often positioned as close as 15 cm to neonates.

2) Expose as much of the skin surface as possible to the phototherapy light. To maximise skin exposure, dress the baby during a nappy and their protective eye coverings only.

3) Cover the eyes with appropriate opaque eye covers e.g. Natus Biliband Eye Protector.

4) Ensure that phototherapy unit is turned off during collection of blood for TSB/SBR levels, as both conjugated and unconjugated bilirubin are photo-oxidized when exposed to white or ultraviolet light.

Documentation in the neonates discharge letter and Child Health Booklet should include details about TSB/SBR levels and duration of phototherapy treatment [4].

D. Types of Phototherapy

There are 2 major types of phototherapy used till date.

1) **Conventional Phototherapy** – where the infant is laid under a halogen or fluorescent lamp with their eyes covered maybe with a nappy.

2) **Fibreoptic Phototherapy** – where the infant lies on a blanket that has fibre optic cables embedded in it. light travels through the fibre optic cables and shines on to the baby's back.

In the two strategies for phototherapy, the point is to uncover infant's skin to however much light as could be expected.

In most cases, generally conventional phototherapy is first to be attempted. fibreoptic phototherapy could likewise be utilized if infant was born prematurely and likely to be more comfortable.

These types of phototherapy are not applied continuously but stopped for 30 minutes every 3 hours so you can feed your baby, change their nappy and give them a cuddle to feel comfort. If the baby's jaundice doesn't improve after conventional or fibreoptic phototherapy, phototherapy may be continued until it improves. This involves using more than one light in conventional case and often a fibreoptic blanket at the same time [4].

During phototherapy, if the baby is becoming dehydrated then Intravenous fluids may be given to infant. The bilirubin levels will be monitored periodically and treatment is going on till bilirubin level falls to a safe level.

II. DESIGN & CONSTRUCTION

As it is investigated that Conventional Phototherapy and Fibreoptic Phototherapy both have their limitations and advantages. In developing nation majorly Conventional Phototherapy is used and it is required to upgrade that, under this vision our first aim in order to design and developing the bed to provide complete comfort to the infant because they are suffering from the jaundice and ulcers. The objective of this design and research is to resolve the issue of pressure points and make sure that the maximum body is expose in light during phototherapy especially the focus is being to expose the back side of infant to phototherapy, it is done by developing lateral tilting of mechanical bed and providing a special design in the bed.

The lateral tilting mechanism in the bed is used to improve physical activity of the infant, improve the blood circulation and thus reduce the pressure points and other contributing factors.

The other motive is to developed low cost hospital bed and making it affordable even for middle class and poor people. So that this bed is just adjusted to pre-existing NICU units.

A. Major contributing factors for design includes:

1) Mechanical loading (shear, friction, pressure)
2) Mobility
3) Time
4) Skin friendly
5) Microclimate like moisture and temperature.

B. Mobility /Tilting:

First we talk about mobility and tilting for preventing the infants by high intensity UV light. A randomised control trail was conducted by Moore Z and Seamus during 2006-2009 to determine the effect of 30-degree repositioning technique during the treatment of infant.

After this trail become successful it is said that, change the position of the infant in every three hours in a day and high risk due to pressure [9].

C. Time:

Later a study was conducted by Vandervee i.e. for finding effectiveness of repositioning patients lying on a pressure reducing mattress alternatively for 2 hours in lateral position and 4 hours in supine

position reduce the incidence of pressure ulcer in comparison with repositioning every 4 hours [9].

This bed should be designed as single unit with multiple facilities like multiple tilting using the following design criteria:

1) Design of bed should be single and easy to operate.
2) Movement of patient should be minimum.
3)It should be providing additional facility.
4) It should reduce the effect of work/assistance required to manage bed rider patients.

D. Parameter to be consider for designing of bed:

The bed is to be designed on the basis of 95th percentile height and weight of the patient body.
The material used for the fabrication of the bed should also be available at low cost and also simple mechanism should be used to get different motion and adjustments. Safety of patient and care taker is at most important. Design must be user friendly. Final design of bed consist of base structure frame with four legs on which main frame is supported.

Main Frame Consists: -

1) Air mattress /Silicon sheet
2) A source of Bili light/LED light
3) An air compressor
4) A pressure regulator

E. Design of Air Mattress/Silicon Sheet:

1) The structural layout of air mattress which is used in the treatment would be in the form of bubbles and cross sectional arrangement of the sheet.
2) The material that we are going to use for this mattress might be silicon or PVC (Poly Vinyl Chloride).
3) With the help of air compressor, we have to fill the air in the cross sectional sheet arrangement according to the ease and comfort of the patient and infants.
4) According to study we mentioned above, it is very important to repositioning of the infants alternatively for 2 hours in lateral position and for 4 hours in supine position for the prevention of pressure ulcers and sores during the phototherapy treatment.

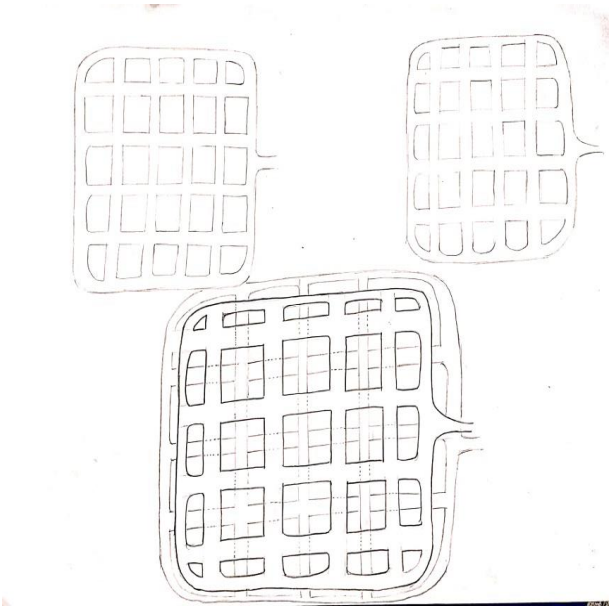

Figure 1 : Proposed design of Bed

F. Design of Source of Phototherapy Light:

In phototherapy a special type of LED's and Bili light are used (not sunlight).

There are two ways: We can have laid down the baby under a halogen or florescent lamp with their eyes covered. The second way is your baby lies on a blanket that incorporate fibre optic cables light travel through the fibre optic cables and shines on back of infant. In both methods of phototherapy, the aim is to expose your baby's skin as much light as possible. In our design both targets have been achieved with the focusing of Pressure points.

Air Compressor and Regulator Air compressor and pressure regulator would be used just providing the air and regulating the pressure linearly (so that pressure points of body are not effected) to the air mattress.

G. Material to be Used for Making of Bed

Silicon is that the most abundant electropositive element within the Earth's crust. It is usually tetravalent in its compounds, although sometimes its bivalent, and it's purely electropositive in its chemical behavior.

Natural silicon contains 92.2% of the isotope 28, 4.7% of silicon 29 and 3.1% of silicon 30. Apart from those stable natural isotopes, various radiactive artificial isotopes are known.

It forms various series of hydrides, various halides (many of which contain silicon-silicon bounds) and lots of series of compounds which contain oxygen, which may have ionic or covalent properties.

H. Health Effects of Silicon

Silicon concentrates in no particular organ of the body but is found mainly in in connective tissues and skin. Silicon is non-toxic because the element and all together its natural forms, namely silica and silicates, which are the for most abundant. Silicone technology has brought revolution within the textile industry because it plays an crucial role in textile manufacturing process. The new age discovery of silicone technology enables textile manufacturers to make functional fabrics, high performance and intelligent textiles, which may satisfy the stress of consumers.

Silicone is an odorless, colorless, non-oily cleaning agent that is used in dry cleaning to carry detergent to clothes and rinse away suspended dirt and oils trapped by the detergent. Silicones used as fabric softeners to help preserve textiles due to their softening properties.

III. WORKING OF BED

It works on the principle of pressure points variation and regulation of atmospheric pressure within the bed.

As per the planning shown within the figure given below there's double net sort of inflating and deflating bed is use for the treatment of infant.

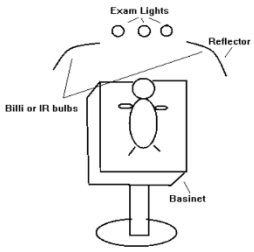

Figure 2 : working of bed [1]

1) However, it's easy to know the working when the air is entering into the pipe of the bed then it passes through different path of the inside-net and filled inside-net thanks to which it swells up the bed and supply support to the infant and therefore lamp/light source which provides the treatment is passes through the body of the infant and breakdown the bilirubin.
2) If the infant place on the bed and remains same position because the baby don't change position during their infant stage then the exposure of sunshine is continuous on an equivalent part of body and therefore the back of the baby is effected because of rashes and cutting of body of baby also don't maintain proper exposure of sunshine this problem is solved in our model here we are using two nets of bed and both are in inflating and deflating position which suggested that it pump and suck the air from the bed thanks to which the pressure points on the body is changes during in a continuous manner.
3) The basic need of our model is to supply proper comfort of the body of infant and proper exposure of sunshine so it can treat infant within the required duration of your time.

4) When air enter in first one then other one is empty and not crammed with air while when second is filled up air then first one is unfilled with air.

A. **Sort of Light Used**

Phototherapy involves shining fluorescent light from the bili lights on bare skin. A selected wavelength of sunshine can break down bilirubin into a form that the body can get obviate through the urine and stools. The sunshine looks blue. The newborn is placed under the lights without clothes or simply wearing a diaper.

B. **Bili Lights**

Bili lights are a kind of sunshine therapy (phototherapy) that's wont to treat newborn jaundice. Jaundice may be a yellow coloring of the skin and eyes. It's caused by an excessive amount of a yellow substance called bilirubin. Bilirubin is made when the body replaces old red blood cells with new ones.

C. **Wavelength**

Light within the 460-490 nm wavelength is perhaps the for most effective to be used during phototherapy. Conclusion Phototherapy with a 20 cm distance between the sunshine source and therefore the neonate is simpler than a 40 cm distance for decreasing bilirubin levels at 24 hours in newborns with hyperbilirubinemia.

Phototherapy leads to transformation of bilirubin to more water-soluble isomers. The efficacy of monochromatic light from 350 to 550 nm within the fastest photoisomerization reaction was quantitated by high-pressure liquid chromatography [2]. The for most effective wavelengths in vitro (i.e., resulting in greater than 25% photo isomer) were within the blue spectrum from approximately 390 to 470 nm [10].

Green light (530 nm) wasn't only ineffective for production of photo isomer, but capable of reversing the reaction. The results indicate that any clinically useful phototherapy unit must include the blue portion of the visible spectrum, and suggest that the effectiveness of phototherapy could also be increased by elimination of green light [2].

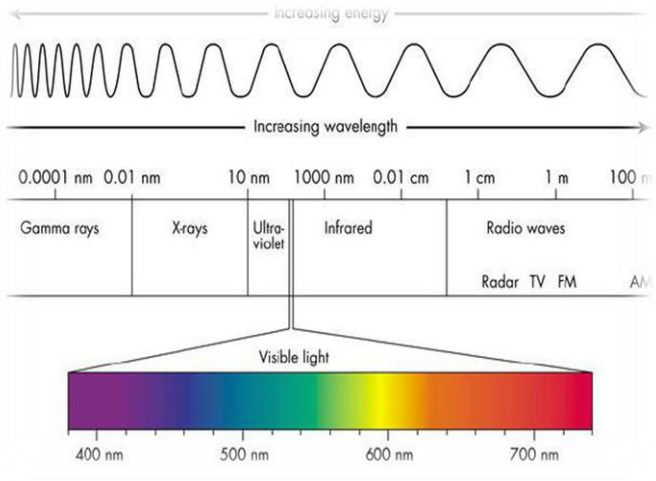

Figure 2: spectrum of wavelength [2]

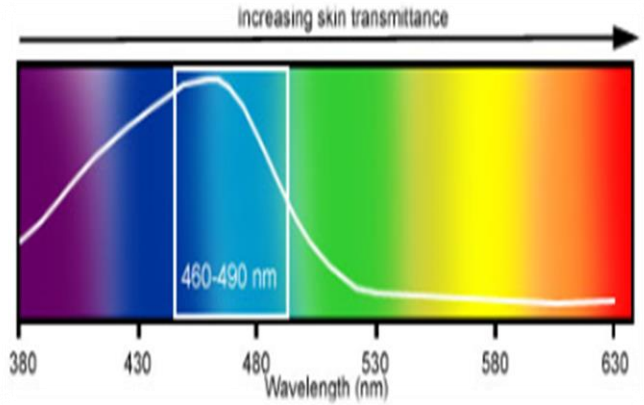

Figure 3: spectrum of wavelength [2]

IV. CONCLUSION

The whole study is given a foundation for further collaboration of engineering with medical science and need. This design is useful for treatment of infant who are suffering from Jaundice. As in developing countries this is need of such a system which fits on pre-existing NICU without going much cost. Whether this technique requires more study to determine the

various effects, further clinical trials are also required at last stage of this design.

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