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PHOTOTHERAPY: A MODERN EXTENSION OF *SWEDANA CHIKITSA* FOR NEONATAL JAUNDICE

Srivastava Mayank*

Professor & Head, Department of Kaumarbhritya/ Bal Roga, Himalayee Ayurvedic Medical (P.G.) College & Hospital, Dehradun, India.

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***Corresponding Author**
Srivastava Mayank
Professor & Head,
Department of
Kaumarbhritya/ Bal Roga,
Himalayee Ayurvedic
Medical (P.G.) College &
Hospital, Dehradun, India.

ABSTRACT

During the first week of life of a neonate, jaundice is an important cause of concern due to an associated risk of Kernicterus. Not much is said directly in ancient Indian medical literatures about neonatal jaundice or its management. Rise in *Ama Rupa* of bilrubin (the unconjugated bilirubin), its spread by *Vata* and the *Kapha* (the biological functional entities) dominant phase of life are three core issues which need to be addressed for its management on *Ayurvedic* lines. *Atapa Sweda* (of rising sun) being a mild and effective way of *Vata Kapha Shamana* (pacification) and *Amapachana* can be used in its management, reinforced by the fact that *Atharveda* itself had recommended the use of *Gorohita* (reddish) coloured sunrays for curing *Kamala* (Jaundice). Modern phototherapy can be considered as a refined method of *Atapa Swedana* for processing the *Ama* form of bilirubin and phototherapy lights seem to be a judicious mix of nine properties of *Swedana Dravyas* (drugs causing perspiration). Newer phototherapy lights prepared by satisfying both *Ayurveda* and modern criteria may prove to be more safe and efficacious. This paper also demonstrates the importance of harmonious cross system learning and vice versa validation of concepts for devising safer and effective methods of treatment, apart from exploring the inner scientific logic of *Ayurveda.*

KEYWORDS: *Atapa Swedana, Ayurveda,* Neonatal jaundice, Phototherapy, Unconjugated bilirubin.

INTRODUCTION

Jaundice (*Kamala*) is the commonest abnormal physical finding during first week of life of a neonate. Over two third newborns develop clinical jaundice and by adult standards, almost all newborn babies are jaundiced during their early days of life. Neonatal jaundice is mostly physiological albeit it may be pathological too - whereas 60% of term and 80% of preterm suffer from physiological jaundice, only 5% of newborns suffer from pathological jaundice.[1] So, in general neonatal jaundice is considered synonymous with physiological jaundice and in turn with primarily unconjugated hyperbilirubinemia.

This unique type of jaundice, 'the physiological jaundice', occurs only in the neonates primarily because of transient deficiency of bilirubin conjugatory enzymes on account of immaturity of liver due to which the unconjugated bilirubin starts building up in the blood. As long as the serum bilirubin level remains below the permissible levels, nothing needs to be done but thereafter with rising serum bilirubin levels, the risk of Kernicterus goes on increasing. No matter which system of medicine is used, the management of neonatal jaundice revolves around the target of keeping serum bilirubin below the permissible levels until the liver is mature enough to sufficiently start performing its lifelong function of bilirubin conjugation to ensure its safe disposal. As per modern medicine, this is mostly achievable by phototherapy alone; failing which exchange blood transfusion will be required along with phototherapy. Not much is said directly in ancient Indian medical literatures about neonatal jaundice or its management. Nevertheless these literatures being highly codified storehouses of ancient medical wisdom,[2] every disease has not been given a name albeit each and every health issue of all times and their probable management may be deciphered on careful study of these literatures in the background of a sufficient knowledge of allied literatures. Neonatal jaundice is a good example of such disease, it being indicated at an instance in the form of *Piscachi Jataharini*;[3] whereas the management of this unique form of jaundice may be chalked out on *Ayurvedic* principles, keeping three core issues in mind - rise in *Ama* form of bilrubin (the unconjugated bilirubin), role of *Vata* (a biological functional entity) in spreading this *Ama* bilirubin and the *Kapha* dominant phase of life (childhood).

Atapa Sweda (here of rising sun), a form of *Niragni Sweda* is a mild and effective way of *Vata - Kapha Shamana* (pacification) and *Ama Pachana* (digest and / or metabolise), [4] besides being easy to administer all throughout the surface of skin, the site of *Vata*. Hence it proves to be an ideal natural treatment modality for neonatal jaundice, reinforced by the fact

that *Atharveda* itself had recommended the use of *Gorohita* (reddish) coloured sunrays for curing the *Kamala*.[5] The aforesaid colour being the colour of rising sun is available only for a limited period; but for any type of phototherapy to be effective, it needs to be administered for prolonged duration (apart from other requirements). With the availability of pure spectrum lights of high irradiance, this natural restriction in safer management of physiological jaundice has virtually been eliminated. The roots of modern phototherapy can thus be traced back to *Atapa Sweda* and interestingly their principles also look strikingly compatible with each other, as evident from following section of review and discussion.

REVIEW AND DISCUSSION

The cause of Neonatal Jaundice

This unique form of *Kamala* occurs due to the maturing liver being temporarily unable to handle the loads of the physiologically produced bilirubin and hence this condition starts resolving by itself within a week or two in the majority of neonates. It occurs only in the neonates because of:

- RBC factors: physiological polycythemia, shorter life span of RBCs (in neonates the *Mala* of *Rakta Dhatu – Pitta* Is physiologically increased, albeit temporarily).
- Hepatic factors: due to limited hepatic uptake, conjugation and excretion of bilirubin. It occurs due to transient deficiency of γ and z acceptor proteins and UDP glucuronyl transferase enzyme (seems to have a role of *Kapha*, which in its physiological excess stage of life, by virtue of its *Manda Guna*,[6] decelerates the maturity of the enzyme).
- Gastrointestinal (GIT) factors: enhanced enterohepatic circulation of bilirubin. It occurs due to overactivity of *β*-glucuronidase in duodenum causing rapid deconjugation of the conjugated bilirubin excreted in GIT, thereby increasing its reabsorption from GIT.
- For aforesaid reasons, it is the unconjugated fraction of bilirubin that is primarily elevated in physiological jaundice.

The reason for concern

The unconjugated bilirubin remains bound to albumin and hence cannot cross the cell wall. But with rising unconjugated serum bilirubin levels, the bilirubin binding capacity of albumin gets exhausted and thereafter it starts diffusing across the interstitial compartment, where it binds to tissue proteins and becomes clinically visible as icterus. Finally as this mechanism also starts exhausting, the unconjugated bilirubin starts seeping across the blood brain barrier and comes in contact with neuron's H^+ to form a stable compound bilirubinic acid (BH2).

This causes irreversible damage to the structure of neuronal membrane (hence the brain), eventually causing bilirubin encephalopathy (Kernicterus). Thereafter, either the baby dies, or if survives, is very likely to suffer from the lifelong crippling disease of cerebral palsy.

This binding of bilirubin to tissue proteins and eventually the brain cells (BH2), thus preventing the excretion of this 'vitiated *Dosha*' i.e., *Mala*, is equivalent to *prasara* (spread) of *Doshas* (*Malas)* to *Shakha-Marma-Asthi-Sandhi*. The pathological progress in physiological jaundice is thus clearly seen to follow the trajectory of *Ayurvedic* pathological stages, *Kriyakala*, which ends as *Bhedavastha* in the form of Kernicterus.

Principles of management

General considerations

Due to its unique pathogenesis, coupled with its occurrence in a critical developmental phase of brain, treatment of jaundice in a neonate is grossly different from that occurring in post neonatal age onwards. Its management may be planned on *Ayurvedic* principles, keeping following issues in mind:-

1. Delayed maturity of enzymes- indicating a role of *Kapha*, the predominant *Tridosha* in this age.
2. Stagnation of the toxic and unexcretable form of bilirubin, the unconjugated bilirubin – the *Ama Rupa* of bilrubin.
3. With rising serum bilirubin levels, icterus becomes progressively visible throughout the skin (Kramer's criteria) – *Vayu* is responsible for spreading (*Meghawata*) [7] the *Pitta* thoroughout the body (*Prasara* to *Shakhas*), reflected by a gradual appearance of icterus on the skin. Skin being the seat of *Vata*, aggravation of *Vata* and in turn this condition is translated in the form of increasing icterus on the skin. Unabated, this *vayu* may thereafter deposit this *Pitta* in the brain *Marma* (vital body part) to make the baby a permanent *Vata rogi* in the form of Kernicterus induced cerebral palsy (CP).

Hence for successful management of this condition, we need *Amapachana* and *Kapha* Shamana along with *Shamana* (pacification) of the vitiated *Vata*. So this situation can be managed on two lines:-

I. By increasing the elimination of unexcretable toxic fat soluble (*Ama*) bilirubin – the unconjugated bilirubin, by converting it into excretable forms *(Pachana* and *Shodhana).*

II. by hastening the maturity of the aforesaid enzymes (*Pachana* and *Kapha Shamana*) *Ayurvedic* vewpoint

- *Shodhana* (elimination/ purifactory) and *Shamana* (palliation) are the two basic modes of treatment in *Ayurvedic* system of medicine.[8]
- Widespread and deep seated vitiated *Doshas* as here in neonatal jaundice do not come out from the body by simple treatments and need some special purificatory procedures as *Panchakarma* for their removal. For the removal of *Pitta* (unconjugated bilirubin = *Mala*), it needs to be brought back to *Koshtha*. But in physiological jaundice, the *Pitta* being in *Amavastha* and that too in *Neonates* (children), *Panchakarma* will not be advisable.[9] Here, the fat soluble (unconjugated) bilirubin can be considered as the *Amavastha* of bilirubin whereas its succeeding water soluble form being the *Niramavastha*.
- The idea central to the management of this condition is to avoid the spread of the toxic unconjugated bilirubin to brain, for which excessive vitiation of *Vayu* needs to be checked. In this regard, a fact worth considering is that the severity of neonatal jaundice is seen to increase in a direct proportion to the visible spread of icterus on the skin, the seat of *Vata*. So in order to have a pronounced effect on *vata*, a treatment applicable to a larger surface area of skin is required. But besides *Vata Shamana* effect, the treatment should also have a specific *Amapachana* and *Kapha Shamana* property. The *Atapa sweda* seems to satisfy all the above criteria and hence can be used in management of neonatal jaundice.
- Not much is said directly in ancient Indian medical literatures about neonatal jaundice or any specific management of this condition, including *Swedana*. *Charaka* had described *Atapa Sweda* (sunlight) as a type of *Anagni sweda* and indicated it in management of *Sidhma Kustha*, though not in jaundice. It is in *Atharveda* that a reference regarding use of sunrays of *Gorohita* (reddish) colour, for curing the *Kamala* is present. Here, *Kamala* can be taken to be neonatal jaundice because as per *Ayurvedic* principles of treatment, *Swedana* stands contraindicated in *Kamala*, it being a *Pitta* predominant disease. The aforesaid *Gorohita* color points towards the therapeutic utility of only the rising sunrays in neonatal jaundice. The fact that unconjugated bilirubin present in skin absorbs maximally the 420 - 460 nm (= blue-green light) range of visible light, supports the use of *Atapa* (rising sunlight) *Sevana* as a *Shodhana* therapy for processing and removing the unconjugated bilirubin.
- *Swedana* is an extremely important and universally indicated preparatory procedure of *Panchakarma*, except in diseases where there is an extreme aggravation of *Pitta Dosha*,

as in jaundice.[10] But as bilirubin remains in *Amavastha* in this unique type of jaundice, *Swedana* can be performed in neonatal jaundice. Here *Swedana* is seen to work primarily by its *Amapachana* and *Vata Shamana* effect.

- According to *Dalhana*, the commentator of *Sushruta*, *Swedana* may be practised basically in two ways:- as a preparatory procedure (*Poorvakarma*) in *Shodhana Chikitsa* and as a wholesome treatment in itself (*Pradhana Chikitsa*) in *Shamana Chikitsa*. *Keraliya Panchakarma* is a perfect example as to how *swedana* can be used as a complete treatment modality in itself and not merely as a preparatory procedure.
- Practised in *Sanshamniya* way, *Swedana* acts by digestion (*Pachana*) of the *Sama dosha*. Due to the *Rooksha Guna* of *Swedana*, the *Agni* enhances (*Deepta*) and hence does the *Dhatvagni*. As a result *Ama Pachana* occurs, which in turn makes the skin softer (*Mridu*) and the *Srotasa* (body channels) get cleared off of *Ama* (the unconjugated bilirubin). *Swedana* in itself is also a highly effective and powerful method of treatment of *Vata* and *Kapha* disorders.
- Practised in *Sanshodhaniya* way, *Snehana* is done prior to *Swedana*, which serves to loosen up the *Doshas* in *Shakhas* and *Marmas*. Thereafter on performing *Swedana*, these *Doshas Klinna* with *Sneha* can be easily brought to the GIT and then removed out of the body through the nearest passage.
- In neonatal jaundice, *Swedana* should be practised in *Sanshamaniya* way for previously explained reasons. Here, *Snehana* is not done prior to *Swedana* because of three reasons - firstly because here it is practised in *Sanshamaniya* way, secondly because the baby is already *Swabhavtaha Snigdha* in this stage of life and thirdly because in *Ama* conditions, direct *Swedana* without *Snehana* is recommended.

Modern viewpoint

- As per modern medicine, the use of light for a specific therapeutic purpose is termed as phototherapy. Conventionally as well as in the present explanation, it stands for use of light in treatment of neonatal hyperbilirubinemia. It was first introduced by Kramer and his colleagues in 1985 when they noticed that exposure of premature infants to sunlight or blue fluorescent light lead to a fall in concentration of serum bilirubin. [11]
- For safe and effective *Atapa Sweda*, only the early morning rising sunrays are advisable; but for effective phototherapy, the exposure should be longer and uninterrupted. To tide over this natural limitation, the modern science has now come up with artificial lights emitting primarily the required wavelengths only and has thus revolutionized the concept

of *Atapa Sweda* in management of neonatal jaundice. The *Atapa Sweda* has thus metamorphosed today as phototherapy and it being easy to use, more effective, relatively non-invasive and safe, has emerged as a widely used modality for treatment of neonatal indirect hyperbilirubinemia.

- As the unconjugated bilirubin present in skin absorbs visible light in 400-500 nm range, any light source with significant output in this region of visible spectrum will be effective in phototherapy. So broad spectrum day light, white, blue, special narrow spectrum (super) blue and less often green lights have all been effective in reducing serum bilirubin levels.

Indications of Phototherapy, the modified form of *Atapa Swedana* in neonatal jaundice

- In neonatal jaundice where jaundice occurs due to a rise in unconjugated fraction of bilirubin *(Ama*), inturn raising the serum bilirubin levels to more than that accepted for the maturity, postnatal age and weight of neonate, but is still less than the level at which exchange blood transfusion needs to be done.
- Though difference of opinion exists, it is recommended to be initiated when serum bilirubin due to any cause approaches 12-15 mg/ dl in term and 10-12 mg/ dl in preterm babies.[12]
- In general, *Swedana* is advisable in *Sarvanga Vata*, *Ama Dosha*, *Aayasa*, [13] corresponding respectively to the spread of unconjugated bilirubin, unconjugated bilirubin itself and the CNS complications here.

Contraindications of phototherapy

- *Swedana ayogya*: [14] *Raktapitta* (Hemolytic disease of newborn, Porphyria, etc.), *Pitta Pradhana* (conjugated hyperbilirubinemia) diseases, etc.
- Using it as an isolated therapy when EBT is indicated for removal of antibodies in rapidly rising serum biliribin.

Mode of action of Phototherapy

Modern perspective

1. **Configurational isomerization: - [the reversible step]**

The scarcely water soluble and hence toxic form of unconjugated biliribin ‘Z- isomers’ get converted to more water soluble & hence non toxic unconjugated from,whereas the ‘E-isomers’ get excreted in bile without the need for conjugation.This reaction is instantaneous

on exposure to light, but reversible as soon as the photo- isomer reaches bile duct. So even after 8-12 hours of phototherapy this constitutes about 25% of total serum bilirubin (TSB).

2. Structural isomerization: - [the irreversible step]

Phototherapy also converts native bilirubin by an irreversible reaction to the structural isomer lumirubin, which gets easily excreted by kidneys in unconjugated state. This product forms 2-6% of total serum bilirubin. This reaction occurs in a direct proportional to the dose of phototherapy.This mechanism being more efficient, is mainly responsible for phototherapy induced decline of total serum biliribin.

3. Photo - oxidation: - [a minor reaction]

A small portion of bilirubin gets oxidized by phototherapy to 'photocatabolites' as biliverdin, which gets excreted into bile and feces and to a lesser extent in urine.

Phototherapy also enhances hepatic excretion of unconjugated bilirubin into the intestinal lumen.

Ayurvedic perspective

Skin is considered to be the site of *Vata*; the kernicterus and concomitant cerebral palsy is definitely a *Vata Roga*. Phototherapy in fact acts in the *Prasaravastha* of neonatal jaundice during which *Vata* is spreading the *Ama* form of *Pitta* throughout the body. This widespread treatment applied directly to the seat of *Vata* i.e., skin quickly causes pacification and *Anulomana* of *Vata* along with the special *Amapachana* effect of the therapeutically effective wavelengths, resulting in metabolism to excretable metabolites. If timely *Vatashamana* is not done, the aggravated *Vata* goes on to deposit *Pitta* in brain (*Sthanasanshraya*). This being an irreversible process (Kernicterus), the baby becomes a permanent *Vata rogi* (CP) and will thereafter require a lifelong management of this established *Vata Roga*.

So by now it's quite evident that Phototherapy is nothing but a modified form of *Swedana*, used for processing *Ama* – the unconjugated fraction of bilirubin. It is infact a *Shodhana Chikitsa* performed by means of *Sarvanga Niragni Swedana* via refined lights Here it is worth mentioning that the *Nirukti* of *Sweda* connotes two meanings[15] '*Paka Bheda*' (*Pachana*) and 'the sweat' (sweating). In neonatal jaundice, it is the first meaning (*Pachana*) that holds well. The mode of action of phototherapy as per modern science seems to offer a

biochemical explanation to the ancient Indian therapeutic recommendation of *Atapa sweda* in jaundice.

Qualities required in therapeutically effective phototherapy lights

Ayurvedic perspective

Two important properties,[16] worth considering in this respect are

- **Ushna (hot)**

For phototherapy to be effective, bilirubin (unconjugated) needs to be present in skin (till 2 mm depth from epidermis).By virtue of *Ushna* property of *Swedana*, vasodilatation occurs, as a result of which bilirubin comes close to the surface of skin and thus the effect of Phototherapy gets augmented. But on the other hand, it can cause complications as burns and hence modern method of phototherapy prefers cutting down this property to bare minimum in phototherapy lights; infact in biliblankets it has almost been eliminated to zero, as a result of which the infant can be directly laid down upon it, for ensuring delivery of maximum flux to the baby. In phototherapy, heating effect or killing of microorganisms is not needed, so UV and infra red wavelength (richer in *Ushna* and *Sookshma Gunas*) rich duration of sunlight should be avoided or alternatively, one may use artificial lamps devoid of such wavelengths. This property thus correlates well with the flu or intensity of the light.

- **Tikshna (sharp)**

This property is responsible for higher penetration. But as the penetration increases, chances of damage the DNA, skin malignancies, etc also increases. In general it causes *Daha*, *Paka* and *Srava*, by virtue of which the unconjugated bilirubin bound to tissues gets alternatively metabolized (*Amapachana*) and thus get mobilised as excretable water soluble catabolites (*Shodhana* by *Anulomana*, *Prerana* and *Pravrittisheela*). But for achieving these effects safely, phototherapy lights should emit only the required wavelengths and the unwanted ones as infrared and UV should be abandoned. So, augmented blue lights are preferred. This property thus correlates well with the wavelength of the light.

Modern perspective

- The two prime determinants of efficacy of phototherapy lights are its wavelength and intensity.
- Bilirubin is a yellow pigment and hence it is capable of absorbing photons of violet blue and some green spectrum of light. So when a broad spectrum white light is used, only a

fraction of light affects the bilirubin. Maximum absorption peak of bilirubin is 450-460 nm (blue green spectrum). So most effective lights will be those that emit this particular range of wavelength and that too in a high amount, i.e., flux/ intensity /irradiance (delivery of high irradiance in this particular range of wavelength). Generally with increasing flux, heat (infrared radiations) and UV radiation tend to increase. So, increasing the irradiance increases the efficacy, until the saturation dose of 40 µw/cm^2/nm of appropriate light is reached. Special blue lamps with a peak output of 425-475 nm are most effective for Phototherapy, as they do not emit UV rays. For effective Phototherapy, minimum 'spectral radiance' should be 4-5 µw/cm^2/nm.[17]

- In past when obtaining pure spectrum lights of high irradiance were not possible, rising sunlight used to be the best measure for managing neonatal jaundice. But today with the availability of light sources emitting only desired spectrum of wavelength, sunlight is no longer a preferred method of phototherapy.
- High intensity blue, green daylight, white cool or gold lights are now available in market for use in phototherapy. Blue (approx. 450 nm) is better absorbed then green. Green light (because of longer wavelength) penetrates the skin more deeply, but with no extra advantage. Green light may cause erythema & subsequent tanning of skin**.** Gold light decreases some of the side effect of blue light especially when special blue light bulbs (enriched blue lights) are used, but is ineffective by itself in reducing serum bilirubin.

  Narrow spectrum lights are almost free of infra red and UV radiations; in other words such lights are richer only in the *Gunas* (qualities) required for the therapeutic effect. Being less *Ushna* and *Tikshna*, exposure to such lights also does not cause significant sweating (in compliance with aforesaid *Nirukti* of *Sweda*). In a nutshell, such lights have a higher therapeutic index. The various wavelengths of lights can thus be therapeutically classified in an *Ayurvedic* way, on the basis of relative amount of the nine properties of *Swedana Dravyas* in various degrees (in a '*tara –tama*' way).

Other issues worth considering while administering phototherapy

Swedana (and hence phototherapy) according to severity of jaundice

Apart from the spectrum and irradiance of the light delivered, the effectiveness of phototherapy also depends upon the distance of light source from the infant and the surface area of infant exposed to it. *Swedana* and hence phototherapy can thus be[18]

For mild - moderate jaundice

Mridu

If the strength of diseased (i.e., neonate) and the disease is less. Hence, in mild neonatal jaundice, exposure to rising sunlight may be enough. It is also advised for particular body parts as genitals, eyes, etc., and hence during phototherapy, proper shielding of these regions is indicated.

Madhyama – use single surface phototherapy.

For severe jaundice

Mahana sweda **(Intensified Phototherapy)** – use double surface extensive phototherapy.

Precautions

- *Swedana* should not be done on eyes, [18] and genitals. During exposure to Phototherapy lights, eyes should protected by eyepads (to prevent retinal damage) and genitals covered with napkin.
- While administering phototherapy to neonates, hyperthermia and dehydration are also a matter of concern. To minimize such side effects, pure spectrum lights should be used and an optimum ambient temperature should be maintained (25-28°C).To protect heart and circulation, adequate hydration status should be ascertained frequently. The infants on phototherapy should receive an additional 20-40 ml/kg/24 hour fluid, to safeguard against dehydration and hemoconcentration.
- Phototherapy must be provided continuously, except during breastfeeding when it may be switched off. *Intermittent Phototherapy has been shown to be more deleterious*.
- Serum bilirubin should be monitored 12 hourly (or 24 hrly) during Phototherapy, as *clinical evaluation of jaundice on the basis of skin color becomes unreliable in babies receiving phototherapy*.
- Failure of response to phototherapy should not be ignored. If bilirubin rises despite adequate phototherapy, search for a reason, not forgetting to consider the possibility of an ongoing hemolytic process.

Duration of phototherapy (signs of *Samyaka Sweda*)

It is determined by a reasonable fall in serum bilirubin. Intensive Phototherapy *should produce a decline in TSB of 1-2 mg/ dl within 4-6 hrs.* In fact it should decrease TSB *by 30-*

40% in first 24 hr, most significantly being in first 4-6 hrs. Phototherapy may be discontinued once TSB falls to below 15mg/dl.

If response to phototherapy is inadequate (*Ayoga*) i.e., inability to produce a decline of TSB @ 1-2 mg/dl every 4-6 hrs and inability to keep TSB below the exchange range, then EBT, a modified method of *Raktamokshana* and side by side *Tarpana* (with blood) will be needed.

Complications[19]

Immediate

- *Atiyoga*[20] *Pitta Prakopa, Daha, Jvara* and *Trishna* which are comparable to hyperthermia, dehydration and irritability due to enhanced insensible water loss. This can be avoided and managed by administering appropriate fluids to babies, along with monitoring of body weight, serum osmolality & hematocrit.

- A common S/E is passage of loose green stools due to transient lactose intolerance and irritant effect of photocatabolites, causing increased colonic secretory losses.

- **Flea-** Bite rash on trunk & extremities may occur. Rashes are usually mild and self-limiting and disappear rapidly.

- **'Bronze baby syndrome'** – Refers to a dark grayish brown discoloration of skin in some infants on phototherapy; but eventually it disappears without permanent sequelae. It *occurs if Phototherapy is done in presence of raised conjugated bilirubin*, [more than 2 mg % (due to cholestasis & hepatic dysfunction)].

- **Hypocalcaemia-** It may occur possibly due to phototherapy induced inhibition of pineal secretion of melatonin, resulting in direct hypocalcaemic effect of cortisol.

- Photo-oxidant damage to RBCs may cause hemolysis. Platelet turnover may increase in some infants, resulting in low platelet count; though bleeding does not occur.

- Increased risk of opening of Ductus arteriosus in preterm (<32 wks) babies.

Delayed

- Retinal and gonadal damage (can even cause infertility).
- Late anemia and hemolysis.

- Exposure to light may disturb circadian rhythm of sex hormones, thus having potential implications on onset of puberty and future sex behaviour.
- Theoretically increased risk of developing malignancy of skin in later life.
- Intermittent therapy causes more damage to intracellular DNA than continuous exposure to light.

The aforesaid side effects are mainly related to the duration of phototherapy and hence methods which augment the bilirubin clearance will in turn reduce the required duration of to phototherapy and hence the side effects associated with it. So concomitant administration of hepatoregenerative drugs (to accelerate the maturity of hepatic enzymes) or *Swedanopaga Dravyas* selected on aforesaid criteria and use of improved phototherapy lights prepared by satisfying aforesaid *Ayurveda* and modern criteria may further improve the efficacy and safety of phototherapy. A similar cross system learning and vice versa validation of concepts on a single platform is needed for overcoming the lacunas in the laboratory-centred system of medicine, the modern medicine and the life-centred system of medicine, the *Ayurveda*. Transdisciplinary validated and hence safer and more effective methods of treatment may then be developed in an unbiased way for various health issues of the mankind.

CONCLUSIONS

- Phototherapy is a refined method of *Atapa Sweda* for management of neonatal jaundice.
- Although rising sunlight may be effective in mild neonatal jaundice, but for moderate to severe jaundice, phototherapy is needed.
- Most effective lights will be those which emit 450-460 nm range of wavelength in a flux of 40 $\mu w/cm^2/nm$.
- From aetiology to management of neonatal jaundice, *Ayurvedic* and modern system of medicine run on comparable principles.
- Modern phototherapy lights seem to be a judicious mix of the nine properties of *Swedana Dravyas* especially *Ushna* and *Tikshna*.
- Newer phototherapy lights prepared by satisfying both *Ayurveda* and modern criteria may prove to be more safe and effective than presently used phototherapy lights.
- Concomitant administration of *Swedanopaga* and hepatoregenerative drugs may shorten the duration of phototherapy and thus reduce the side effects associated with it.
- Cross system learning is the key to explore the inner scientific logics of this ancient system of medicine.

- Laboratory trials and biochemical explanations are needed to corroborate the statements of *Ayurveda* and induce a global faith in the unique concepts of this time tested system of medicine.
- Vice versa validation of principles can open new dimensions in development of safer and more effective protocols for various health issues.

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