7/92 The Application Of Phototherapy

Introduction

The use of phototherapy is common in many if not all Neonatal Intensive Care Units and this method of treatment is reviewed here following efficiency tests on a considerable number of phototherapy units in hospital NICUs in London, the South East, Midlands and North of England.

A significant amount of phototherapy equipment used for the treatment of neonates with hyperbilirubinaemia produces a low level of useful therapy because the light sources are ineffective. As a consequence the treatment time is extended or the excess bilirubin level is not reduced.

Phototherapy equipment

Most phototherapy equipment comprises a metal stand to which is fitted a light housing. This housing usually contains an array of fluorescent tubes which produce either a blue or white light output, or a combination of blue and white light, which is directed onto the neonate in the incubator or cot.

The function of this type of phototherapy light source is to provide an output over a range of wavelengths with peaks of irradiance (light density) at those wavelengths most suitable for the treatment of jaundice. The different types of tube fitted to phototherapy units exhibit characteristics during their operational life which depend on the chemical phosphors used.

Light with a strong blue content is also produced from phototherapy equipment fitted with a filtered quartz halogen light source. This can emit a relatively high level of therapeutic output compared with the light emissions produced by combinations of fluorescent tubes.

Some radiant warmers used for intensive care of neonates are also provided with phototherapy light attachments having other types of quartz halogen light sources. The useful therapeutic light that these produce depends on the type of light source and the methods used for filtering unwanted radiations.

Another type of phototherapy light source produces a blue/green cold light from an illuminated pad positioned under the neonate. The intensity of the light output can be varied by the user.

Ineffective phototherapy

It is a mistake to assume that just because a phototherapy unit is emitting fluorescent light when it is switched on, it is necessarily providing treatment for the jaundiced patient. Only tubes with a short service life provide useful therapeutic output, old tubes definitely do not.

A visual clue to how long a tube has been in service may be obtained by noting whether or not there is a darkening of the tube ends by rings of degraded phosphor. If there is, it indicates very old tubes which ceased providing a useful therapeutic output a long time ago and need immediate replacement.

Maintenance of phototherapy equipment

The fluorescent tubes should be replaced for new ones as soon as the effective output declines (which is some time before visual degredation is observed). This may be the responsibility of either the Health Authority technical staff or company service staff responsible for maintaining electromedical equipment. They should have the capability, by the use of appropriate instrumentation, to measure the blue content of the light output from the phototherapy equipment and to replace the tubes or halogen light sources for new ones if the useful phototherapy output has fallen to perhaps two thirds of its original value.

In some cases, even new sets of fluorescent tubes produce a relatively low blue light output ranging from 0.30 – 0.45 milliwatts per square centimeter (mW/cm^2). This is not a very effective therapeutic level and as a result the neonates' jaundiced condition may not change as quickly as expected. The minimum course of action in such cases is to replace half of the tubes with the blue tubes specifically designed to have a high therapeutic output.

If there are no maintenance arrangements for the phototherapy equipment and NICU staff do not intend to use measurement instrumentation (see later), they may wish to consider keeping a record of the hours each tube is used. After being in service for about 1500 hours the tubes should be replaced and a new record of operational hours started.

General use

Different NICUs use different combinations of fluorescent tube in their phototherapy units, the types of tube used in order of popularity are:

a. blue tubes.

b. daylight (white tubes)

c. half blue and half daylight tubes.

The most effective treatment is from blue tubes although some nurses in NICUs do not like working near the intense blue colour and visual inspecton of the patient is more difficult. White tubes are cheaper to purchase but generally provide a significantly lower therapeutic output.

A different type of blue fluorescent tube is used for phototherapy in some European hospitals but it is not available yet to the NHS. Its performance appears to be high and investigations are continuing. Further

Technical aspects

The level of effective light output from a phototherapy unit can be measured by an instrument called a radiometer. This is a calibrated indicator coupled to a special light detector and filter. The blue light emitted by the phototherapy under test is detected and the power density is indicated by the instrument. It is usually expressed in milliwatts per square centimeter (mW/cm^2).

The measurement is based on a calibrated average of wavelengths over the blue light range considered the most suitable for the treatment of hyperbilirubinaemia.

A level of irradiance of 1.0 mW/cm^2 or above can be considered suitable for treating the more serious cases of hyperbilirubinaemia. Irradiance levels between 0.45 and 1.0 mW/cm^2 can be considered suitable for less severe cases. Such measurements have clearly to be made at a distance from the phototherapy equipment equivalent to the usual patient distance.

The results of tests the Department made of the output of some phototherapy equipment in NICUs which were fitted with fluorescent tubes of unknown service life gave irradiance measurements between 0.09 and 0.25 mW/cm^2, which were very low. This contrasts with the outputs from some phototherapy units using quartz halogen light sources which can produce outputs of between 1 and 3 mW/cm^2 at the normal patient distance.

NICU staff may wish to consider acquiring a suitable measuring instrument for phototherapy, but prior advice on the type and use of such instrumentation should be sought from the local hospital physics department or the Department of Health at the address given at the end of this section.

Application of phototherapy

It is a feature of phototherapy that the effective therapeutic output directed at the patient varies as the inverse square of the distance, in other words the further the phototherapy unit is from the patient the less will be the phototherapy received.

In most cases, when phototherapy equipment is positioned over the canopies of baby incubators, the distance between the light source and the patient in the incubator is predictable, but when phototherapy is used over cots the distance can vary from cot to cot and this can affect the level of treatment received by the patient even from efficient phototherapy equipment.

The positioning of several items of inefficient phototherapy equipment around the sides of incubator canopies is most likely to be less effective than the use of a single item of phototherapy equipment producing a high output which is positioned over the top of the incubator canopy.

Radiant warmers and phototherapy

Radiant warmers used for intensive care can, if desired, be provided with phototherapy and these usually have halogen light sources. The output from a number of these items of phototherapy equipment were measured using a research radiometer, the detector of which was positioned 100 mm above the centre of the integrated warmer mattress. The results indicated a range of outputs varying from between 0.35 and 0.49 mW/cm^2.

Neonatal eye protection

It is of course essential to cover the eyes of neonates receiving phototherapy and there are different ways of doing this. The problem with eye covering is that it does not always stay in position on the neonate's face because of mobility or restlessness. Commercially available eyepad material, when correctly positioned, is effective and transmission of unwanted light is prevented. Lint and gauze eye pads made locally in the NICU, however, seem to allow some transmission of phototherapy light through the material from the more powerful phototherapy units.

The use of complete headboxes and headbox shields of Amber 300 Perspex is an effective alternative to eye pad protection. The result of tests have shown that this material blocks the transmission of UV and blue light wavelengths.

The added bonus of Amber 300 shields is that visiting parents seem to find them more acceptable than the eyepads. A complete headbox of Amber 300 is the most effective filter as practically all the unwanted light is blocked out. The wide version of Amber headbox shield with open ends is also effective in filtering out the unwanted light over the patient's face and the transmission of unwanted light is reduced to an acceptable level. The narrow version of this type of headbox shield is not as good as too much unwanted light passes through the ends and secondly it is easily moved out of position by the patient.

Use of phototherapy in the home

Home phototherapy is sometimes used for children suffering from Crigler Najjar Syndrome (a UDP glucuronyl transferase deficiency in the liver). The patient may need constant phototherapy for up to 13 hours a day depending upon the severity of the illness. In one particular case investigated by the Department the treatment was from an array of 8 four-foot long blue fluorescent tubes positioned over an adapted cot. The intense blue output from these lights produced an irradiance of about 1.10 mW/cm^2 and this level was effective in keeping the child's bilirubin down. A sheet of Amber 300 Perspex was later positioned over the head end of the cot which provided protection for the patient's eyes rather than the inconvenient eyepads.

It was very important for the therapeutic level of the blue light source to be maintained and the irradiance

closely monitored by the use of appropriate radiometry. If the effective output of this phototherapy declined, the child's condition deteriorated rapidly, especially during the winter months.

The success therefore of this expensive phototherapy treatment relied on the dedication of the child's family and on active assistance from the local hospital.

Conclusion

In establishing more effective phototherapy within the NICU it is necessary to:

1. Assess the condition of the fluorescent tubes used in the phototherapy equipment either by observation or preferably by measuring the effective output.

2. Make arrangements for routine periodic checks of the performance of the phototherapy units.

3. Note that the effectiveness of phototherapy varies as a square of the distance between the light source and the patient.

4. Use efficient phototherapy equipment to avoid wasting time and expense.

5. Remember that phototherapy equipment is electromedical equipment and needs to be maintained as such. It is not just a source of visual illumination to be maintained by hospital departments responsible for the service of general lighting.

References:

Modi: A Guide to Phototherapy for Neonatal Hyperbilirubinaemia.

Marshall / Mosely: Protective Light Shields for Neonatal Phototherapy.

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