CTuS3 Preliminary clinical results of a transcutaneous reflectance spectrophotometer for the detection of bilirubin in neonates

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A reflectance spectrophotometer has been developed for the determination of the bilirubin level in neonates from the transcutaneous, diffuse reflectance in the 380–820 nm wavelength range. It is comprised of a diode-array spectrophotometer (Hewlett Packard 8452A) with the light source and diode-array input modified by a fiber bundle (optical patch). A laptop computer (Toshiba T1200) is used to control the spectrophotometer and collect and store data.

The fraction of reflected light that is collected by the optical patch depends on the optical properties of the tissue measured. The optical patch has been calibrated to calculate the true reflectance (R) of the tissue from the reflectance measured (R_m) with the optical patch at a tissue surface of known scattering coefficient. There is a predictable increase in the scattering coefficient of neonatal skin with gestational maturity of the infant.[1] This variation in the scattering coefficient of neonatal skin can be corrected for predicting the absorbance in the tissue from the measured reflectance.

The reflectance spectra were collected from a racially heterogeneous group of 31 jaundiced neonates. The spectra were measured at four sites (forehead, sternum, abdomen, and forearm) and repeated at 24-hour intervals while the neonate remained jaundiced. Bilirubin absorption is observed in the 460-nm wavelength range of the reflectance spectra. The absorbance in the skin due to melanin and blood is also observed in the reflectance spectra.

The content of high-molecular-weight melanin in the skin can be determined from the slope of the reflectance spectra between 650 and 800 nm, but the low-molecular-weight melanin absorbs wavelengths less than 500 nm.[2] The high-molecular-weight melanin scored in this method varied from 813 to 1700 μO.D./nm for the patients measured. The absorbance due to the low-molecular-weight form of melanin can be deduced at wavelengths lower than the 416-nm blood-absorption peak, because there is no significant bilirubin absorption in that range. Blue light reflected from the surface has traveled, on average, less deeply than longer wavelength light. Therefore, the absorption of blood observed at 416 nm relative to that at 577 nm provides information on the average depth of the blood in the tissue.

The bilirubin absorbance is observed more prominently if the blood vessels, from which the bilirubin seeps into the skin, are more superficial. The wavelength-axis intercept of the uncorrected absorption spectra is a function of both the neonate's gestational age and its melanin content. The gestational age of the neonates can be estimated from the reflectance spectra. Fig. 1 illustrates some of the features of the optical density spectra that are used to determine the bilirubin and melanin content, the blood depth, and gestational age of the infant. Furthermore, the absorption peak observed at 577 nm is related to the hematocrit of the infant. The hematocrit score, $O.D._{577}-O.D._{650}$, where $O.D. = -\log(R_m)$, varied between 0.12 to 0.35 for the jaundiced neonates. Extensive analysis of clinical spectra will facilitate the development of transcutaneous determination of factors other than bilirubin level.

1. Saidi, I. S., S. L. Jacques, and F. K. Tittel, *Proc. 1990 Conf. Lasers Electro. Opt.* (CLEO '90, Anaheim, Ca.), p. 524.
2. Kolias, N. and A. H. Baqer, J. of Invest. Derm. **89**, 384 (1987).

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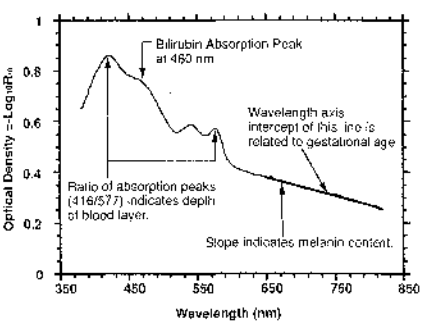

CTuS3 Fig. 1. Typical optical-density spectrum collected from a jaundiced neonate. Optical density is calculated as $-\log_{10}(R_m)$, where $R_m = fR$. R_m is the reflection measured with the optical patch, f is the optical patch efficiency of diffuse light collection for the skin relative to the calibration standard, and R is the true reflection of the tissue. Pertinent spectral features are indicated.