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A pilot study demonstrating the efficacy of transcutaneous bilirubin meters to quantitatively differentiate contusions from Congenital Dermal Melanocytosis

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ABSTRACT

Objective: Congenital Dermal Melanocytosis (CDM) can be difficult to differentiate from contusions. The need for a prompt and accurate diagnosis is best illustrated in cases where child abuse and maltreatment is of concern. Transcutaneous bilirubin (TCB) spectrophotometry has been well established to measure bilirubin under the skin for jaundice in infants. The use of TCB spectrometry has not been used to identify or differentiate contusions from CDM. We hypothesized that bilirubin, a degradation product of hemoglobin, would be elevated in contusions but not in CDM thus demonstrating the efficacy of a novel diagnostic technique to compliment or improve on physical assessment alone.

Methods: Pilot study with thirty-seven infants and children noted to have CDM and fifty-six infants, children and adults with contusions underwent measurement of their lesion with TCB spectrometry. In each patient, the affected skin was scanned along with the adjacent unaffected native skin allowing an internal control for individual pigment variation.

Results: TCB measurements of CDM resulted in lower transcutaneous bilirubin values that were not significantly different from adjacent native skin pigmentation. This was in contrast to cutaneous contusions, which resulted in a higher measured value (mean 5.01 mg/dL) compared to adjacent native tissue (1.24 mg/dL) demonstrating a four-fold increase in measurement at the lesion site ($P < 0.001$). Direct comparison of a ΔTCB value (lesion measurement minus the adjacent tissue) demonstrated a significantly higher value in contusions compared to CDM with a mean value of 3.77 and 0.12 mg/dL, respectively ($P < 0.001$).

Conclusions: TCB Spectrometry as a novel diagnostic technique has the potential to discern contusions from CDM and may therefore have the ability to compliment the use of physical assessment alone.

What is known on this subject

Transcutaneous bilirubin spectrophotometry has been well established to measure bilirubin under the skin for jaundice in infants

Abbreviations: CDM, Congenital Dermal Melanocytosis; TCB, transcutaneous bilirubin; BL, baseline

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but has not been used to identify contusions or differentiate contusions from congenital birthmarks.

What the study adds

Use of Transcutaneous Bilirubin Spectrometry can differentiate skin lesions obtained through trauma from congenital birthmarks. This technique may therefore have utility in the evaluation of children suspected to be victim of child abuse.

1. Introduction

Rates of child maltreatment investigations by child protective services from 2011 to 2015 have increased 9% from 2011 to 2015 to 3,358,000 children (U.S. Department of Health & Human Services, Administration of Children and Families, Aministration on Children, Youth, & Families, Children's Bureau, 2017). In the 2015 Child Maltreatment Annual report, it was estimated that 683,000 children were victim of child abuse and neglect. Of these, 17.2% were physically abused and 1670 children died from child abuse and neglect. Furthermore, a parent of the child victim was the perpetrator in 78.1% of the substantiated cases. Pediatricians, Family Physicians, Emergency Physicians, and Child Abuse Physicians are at the forefront of evaluation of children suspected of abuse. Congenital dermal melanocytosis (CDM), previously known as Mongolian spots, are a common skin finding in children and can be a mimicker of contusions. CDM can be difficult to differentiate from traumatic injury based on visual inspection alone. CDM is relatively permanent, while a contusion progressively fades. Therefore, definitive determination can sometimes only be accomplished in a delayed fashion through follow up. Yet, the need for a prompt and accurate diagnosis is best illustrated in cases where child abuse and maltreatment is of concern. As the contusion heals a color change is appreciated with an eventual yellow appearance representing the degradation of hemoglobin to bilirubin. Prior studies have shown that visual inspection in vivo and photography of contusions have limitations including the qualitative nature of colorimetric change, subjectivity, and poor intra- and inter-observer reliability (Bariciak, Plint, Gaboury, & Bennett, 2003; Langlois & Gresham, 1991; Nichols et al., 2007;Pilling,Vanezis, Perrett, & Johnston, 2010; Stephenson & Bialis, 1996; Wilson, 1977). Langlois et al. looked at the color of bruises for dating, but found that the development of bruise color is variable (Langlois & Gresham, 1991). The colors red, blue, purple, and black could occur anytime from within 1 h of bruising to resolution up to 21 days later. Wilson reviewed forensic pathology studies looking at color changes of bruising including studies by Adelson, Polson & Gee, and Spitz and did not find the color of a bruise to be useful in forensic evaluation (Wilson, 1977). The highly variable nature, the lack of intra- and inter-observer reliability and variations in color of a skin finding makes differentiation of CDM from bruising difficult, especially in situations of limited history and no prior records.

Transcutaneous bilirubin (TCB) spectrophotometry has been well established to accurately and non-invasively measure bilirubin under the skin for jaundice in infants (American Academy of Pediatrics Subcommittee on Hyperbilirubinemia, 2004;El-Beshbishi, Shattuck, Mohammad, & Petersen, 2009; Kazmierczak et al., 2007;Nichols et al., 2007;Tayaba, Gribetz, Gribetz, & Holzman, 1998). These meters work by directing light into the skin and measuring the intensity of specific wavelength that is reflected. The Draeger JM-103 and JM-105 uses two optical paths to measure the optical density difference at two wavelengths. The spectrum of optical signal reflected from the subcutaneous tissues are then converted to electrical signal by a photocell and analyzed by a microprocessor to generate a serum bilirubin value (Raimondi, Lama, & Landolfo, 2012). TCB spectrophotometry has not been used to identify contusions or differentiate contusions from congenital birthmarks. We hypothesized TCB bilirubin measurements would be elevated compared to native pigmented skin in contusions but not in CDM thus allowing a diagnostic technique to compliment or improve on simple visual assessment in evaluation of child maltreatment.

2. Methods

This was an IRB approved (#1605583993) prospective study performed at an academic pediatric medical center using a convenience sample of research staff, newborns, clinic patients, faculty and residents. Thirty-seven infants and children who were noted through history and two-physician confirmation to have CDM underwent transcutaneous bilirubin spectrometry. The affected birthmark and the surrounding areas with native pigmentation were scanned with the TCB meter. Fifty-six infants, children, and adults with contusions known to be acquired through accidental trauma underwent TCB measurements in the same manner. Contusions were found on the extremities, arms and legs in the majority of our samples. Bilirubin measurements were obtained using the Draeger JM-103 and JM-105 TCB meters by research personnel following training on correct use of the device. Inclusion criteria included patients of any age with CDM or contusion used as a convenience sample. Exclusion criteria included non-accidental trauma due to IRB consent restrictions and the high likelihood of a dubious origin in the skin finding.

Table 1 shows the subject demographics. Contusions ranged from 1 to 8 days old at the time of scanning, with an average of 3 days. Of the two newborns, both were scanned at one day of life.

The primary outcome of our study was to determine efficacy of the scanning technique by demonstrating statistical differences between CDM and contusion compared to adjacent native skin pigmentation used as an internal control. Proportions were calculated for categorical data, means, and standard deviations for continuous data. Statistical tests of association for categorical variables were assessed using the chi-square test and paired samples Student's t-test was utilized for continuous variables. All tests were two-sided and the level of significance was set at $\alpha = 0.05$. Statistical analysis was performed using Stata 14 (StataCorp, College Station, TX).