

The HemaCam: A non-intrusive and inexpensive method to detect anemia

February 16, 2006

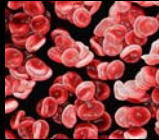
Gregory Jay, M.D./Ph.D, Selim Suner, M.D.,
John McMurdy, Gregory Crawford, Ph.D,



Needs for Anemia Testing

- 3.5 million people in the U.S., 2 billion worldwide with clinically defined anemia ¹
- Millions more Americans undiagnosed ¹
- Shown to cause tachycardia, decrease myocardial function / increase peripheral vasodilation, and as a result increase the risk of heart damage and failure
- Appears concurrent with chronic Kidney Disease (CKD), cancer, diabetes, HIV/AIDS, rheumatoid arthritis, and inflammatory bowel disease



1: World Health Organization, <http://www.who.int>. Image taken from <http://www.udel.edu/Biology/Wags>



Biconcave Erythrocytes

Total Hemoglobin Determination

- Clinical standard for hemoglobin concentration determination is complete blood count (CBC) test (Finger Prick Alternatives)
- Time consuming, expensive, and invasive nature exposes phlebotomist to bloodborne pathogens
- Antiquated in climate of non-invasive optical diagnostics



Images adapted from <http://www.sysmex.com>

Contemporary Noninvasive Methods

- Literature predominantly* utilizing optical signals from cutaneous tissues
- Visible diffuse reflectance spectroscopy and NIR/IR transmission spectroscopy of skin provide insight into hemoglobin concentration


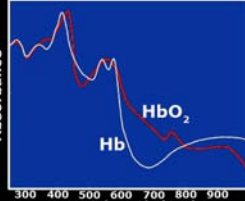




Image adapted from: <http://www.bd.trc.ca>

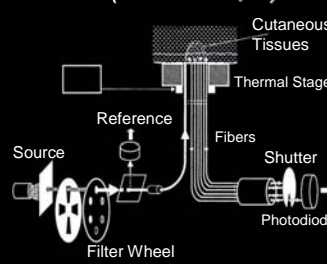
Spectra adapted from Zijlstra et al. *Clinical Chemistry* 37, 1633-1638 (1991)

Representative Configurations

NI-HGB Monitor
Symxex (Kobe, Japan)



Diagnostic Division
Abbott Laboratory
(Abbott Park, IL)




Images Adapted from: Kanashima et al. *J. Clin Anal* 19, 1-5 (2005)

Image taken from: Wu et al. *Anal Biochem* 287, 284-293 (2000)


Palpebral Conjunctiva

Why use the Palpebral Conjunctiva


- Vasculature close to surface and visible in transparent membrane, penetration depths minimal.
- Mucosal surface is less sensitive to melanin variation across ethnicities (sparse dendritic melanocytes)
- Easily accessible location for physicians
- 90% of clinicians report the palpebral conjunctiva hue (PCH) the most attractive qualitative method to diagnosing anemia¹



Caucasian



Hispanic



African-American

1. Hung et al. *Acad Emerg Med* 7, 146-156 (2000)

Varying Conjunctiva Appearance

(a) 7.3 g/dL (b) 12.7 g/dL
(c) 14.0 g/dL (d) 14.5 g/dL

Tarsal Plate/Meibomian Glands
Palpebral Conjunctiva

- Visual Interpretation insensitive to subtle changes in hue
- Clinician observation at best 70% sensitive¹
- Clinician observation is 80-90% specific and 40% sensitive²

1. Ok, Hang et al Acad. Emerg. Med 7, 146-156 (2000) 2. Ali Kiani et al Ophthalmology 109, 274-277 (2000)

Digital Photography Study*

- Digital photographs collected of palpebral conjunctiva
- Algorithm generated based on the intensities of three color channels of camera
- Correlation present, but correlation coefficient and accuracy need improvement

Derived Hemoglobin (g/dL)
CBC Hemoglobin (g/dL)
 $r = 0.5993$
RMSEP = 2.24 g/dL

Arbitrary Reflectance
Arbitrary Transmission
Wavelength (nm)
color fillers
red-edge
Conjunctiva
(d)

* Performed solely at RH and presented in: K.Ernsing, S. Suter, and G.D. Jay Acad Emerg Med 8 528-529 (2001)

Conjunctival Reflectance Spectra


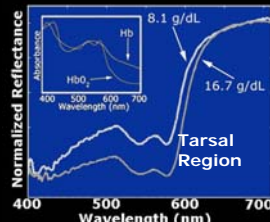
Head Mounts
Subject
Illumination
Collimating Optics
QTH Source
Grating Spectrometer
Zoom Lens
Diffuse Signal

- Illuminate conjunctiva with broadband Quartz-Tungsten-Halogen (QTH) source and collect diffuse reflectance
- Reflectance signal will depend on hemoglobin concentration among other factors

Reflected Signal

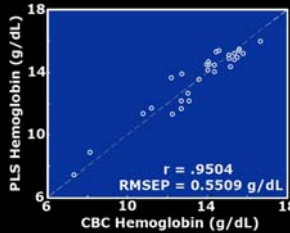
Data Collection

- Multiple diffuse reflectance spectra collected from tarsal plate and forniceal region
- Large aperture integrated numerous vessels to minimize motion artifacts

-Approximate aperture size for acquisition

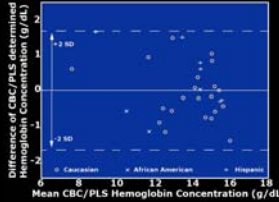
Algorithm Results



$r = .9504$
RMSEP = 0.5509 g/dL

- High correlation using hybrid quadratic and Partial Least Squares model
- Sensitivity ~ 88%
- Specificity ~ 95%

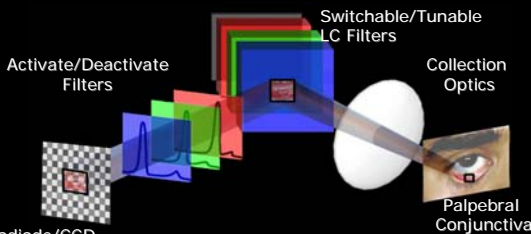
-Bland-Altman Plot shows uniformity of accuracy across ethnicities



J Biomed Optics 11(1) January/February 2006

Liquid Crystal Technology

- Various embodiments of spectrally selective liquid crystal cells can be used in place of grating based spectroscopy



Clinical Embodiment

Inexpensive to Manufacture

Tunable/Switchable Spectral Features*

Other Clinical Uses

Compact/Handheld

Embodiment of a Commercial LC Device

Durable

Commercialization Path

- Start Up Company
 - Possibility of Partnership
- Bridged translational bottlenecks
 - Hardware and Software development
 - Biophotonic applications
 - Develop Near-term clinical translational opportunities
- Brown – Lifespan Cooperative Agreement

