Feasibility and Utility of Continuous Noninvasive Hemoglobin Monitoring in the General Care Setting

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Noninvasive continuous monitoring of hemoglobin (Hb) may help identify patients with critically low Hb or detect changes over time (bleeding)[1-4], and may also reduce patient discomfort, expedite access to results, and make more efficient use of laboratory resources. Availability of Hb trends may assist clinicians in treatment planning and interventions, and allow for earlier recognition of patient deterioration[5]. The goal of the present study was to understand the practicality and impact of using noninvasive continuous Hb monitoring in a general care inpatient setting.

For the three month study duration (Jan-March 2016), 71 beds in two postsurgical units at Dartmouth-Hitchcock (D-H) Medical Center (5630 patient days), were equipped with specialized sensors (Rainbow™, Masimo Corporation, Irvine, California) allowing for direct monitoring of Hb (SpHb), in addition to blood oxygen saturation (SpO2), pulse rate (PR) and perfusion index (PI), which constitute the standard of care for inpatients at D-H. Established patient assessment procedures and alarm configurations for SpO2 and PR remained in use. SpHb alarms cannot be disabled per manufacturer design and therefore maximum thresholds were set for this parameter to reduce possible alarm fatigue. Workflow changed including allowing nurses to request a hemogram if the transcutaneous Hb value was 6 g/dl or less, without the presence of other symptoms. Patient data for each physiological measure, collected at the rate of 1 per second, were recorded and analyzed.

The SpHb data (n≈181.3 million) corresponding to the inpatient population presented a mean value of 11.08 ±0.0002 g/dl, a standard deviation of 1.34 g/dl and an interquartile range of 1.80 g/dl. Whereas the mean value was lower than the normal range cited for laboratory measurements[6], it is consistent with reported data for an inpatient population (~11.79 g/dl)[7].

A histogram of SpHb values versus PI distributions (Fig. 1), showed that 67.38% of the data correspond to SpHb values greater than 6 g/dl and PI values greater than 2.0. A PI value of less than 2.0 generally indicates low perfusion and could imply a low-quality signal for SpHb calculation. PI is subject specific and dependent on various factors including peripheral tissue perfusion, circulatory status, monitoring site, and sensor placement.

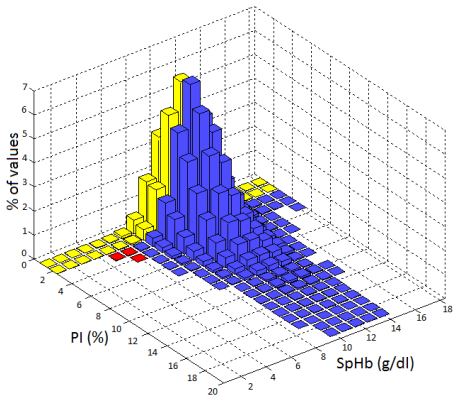

Figure 1. SpHb versus PI histogram. Blue designates *Hb > 6 g/dl and PI > 2%, yellow designates PI values <2%, and red: Hb below 6 g/dl and PI > 2%.*

There were 23.36% fewer valid SpHb data points collected versus the number of SpO2 (or PR, or PI) values. The disparity is likely due to signal confidence, and may be related to alignment of the multispectral sensor. The clinical staff acted upon SpHb values of less than 6 g/dl in a total of 9 instances (1.6 times per 1000 patient days), by requesting hemograms. There were no rescue events triggered as a result of the continuous SpHb measurements during the study period.

A survey of staff satisfaction and system performance was administered (n=32). Responses indicated that correct sensor placement, mainly due to its size, was somewhat challenging, and the weight of the connector cable resulted in patient discomfort (the manufacturer has since redesigned the connector). A lack of confidence in the continuous Hb values was also expressed by staff on occasion, although no evidence to support this was found in a comparison with laboratory data. Comments in the survey illustrate that this response could be due to suboptimal change management activities prior to and during the study. Survey results did show recognition of the necessity and utility of continuous Hb monitoring for patients at an increased risk of bleeding and after transfusions.

In summary, continuous monitoring of Hb in the general care setting is technically feasible with minimal impact on clinical workflow. The system provided fairly reliable continuous output, Hb values were consistent with other studies, and minor design issues encountered with implementation in a general care setting could likely be addressed in a full-scale implementation.

Funding: This project was supported by grant number P30HS024403 from the Agency for Healthcare Research and Quality (AHRQ). The content is solely the responsibility of the authors and does not necessarily represent the official views of the AHRQ.

Acknowledgements: The authors wish to thank the many people at D-H that made this work possible including, George Blike, MD; Jean Coffey, RN, PhD; Krystal McGovern, CCRN; Ken Lee and the Clinical Engineering team; and the RNs and LNAs from 3 West and 4 West.

References:

1. Eipe et al. Indian Journal of Anesthesia. 2006, 50(1): 35-38.
2. Ram et al. Chin J Traumatol. 2014, 17(4): 225-8.

3. Peiris et al. Proc. Soc. Adv. Blood Medicine. 2010, id. 4091.
4. McEvoy et al. Am J Crit Care. 2013, 22 (6): eS1-eS13.
5. Lindner, Exadaktylos. Emerg. Med. Intl. 2013, Article ID 7
6. Vajpayee, Graham, Bem. *Henry's Clinical Diagnosis and Management by Laboratory Methods*. 22nd ed. Elsevier 2011. Ch. 30:509-35.
7. Languasco et al. J. Hosp. Med. 2010 May; 5(5):283-288.