Automated point-of-care processing and interpretation of pulse oximetry for global health applications

Other Conference Item

Author(s):
Karlen, Walter

Publication date:
2019-07-24

Permanent link:
https://doi.org/10.3929/ethz-b-000359389

Funding acknowledgement:
150640 - Intelligent Point-of-Care Monitoring: A Swiss Army Knife Approach to mHealth (SNF)

Automated point-of-care processing and interpretation of pulse oximetry for global health applications

Walter Karlen, *Senior Member, IEEE*

***Abstract*— Pulse oximetry is an essential monitoring tool for global health applications, but widely underused. Reasons are besides the high costs and low robustness of existing devices, the difficulty for health care staff the correct interpretation of the measurements. Technology for automated interpretation of blood oxygen saturation can bridge this gap.**

I. INTRODUCTION

Pulse oximetry provides a non-invasive estimate of blood oxygen saturation (SpO_2) and low SpO_2 (hypoxemia) is an indicator of severe disease. Therefore, pulse oximetry is an essential technology for monitoring in clinical settings to ensure patient safety, derive treatment decisions, and perform diagnoses. For example, pulse oximetry is part of the safe surgery checklist as minimal tool to perform anesthesia monitoring. In the intensive care unit, pulse oximetry guides the administration of oxygen and indicates necessary changes in the ventilator settings. More recently, pulse oximetry has been endorsed as additional tool to respiratory rate measurements to identify severe childhood pneumonia in low resource settings. Supplemental oxygen is an effective treatment for pneumonia. Since oxygen is costly in remote settings, accurate dosage control and timely weaning from treatment through feedback from pulse oximetry can save valuable resources and reduce treatment duration.

Despite the clear need of oximetry in global health applications, universal adoption of oximetry has been slow, impacting patient health and safety. An explanation for the lack of pulse oximeters in low resource settings are the low robustness and quality of the oximeter probes that are not adapted to the setting [1], the high costs [2], and the absence of adequate training [2], [3]. With system integration [4] and reduction of hardware components [5], mobile phone based and portable pulse oximeters have become more affordable and distributable.

Therefore, a major point that remains to be addressed is the adequate usage of the system. Understanding of pulse oximeter technology is not evident and the interpretation of sensor information requires deeper understanding of the respiratory physiology. It is evident that technology could play an important role to bridge this gap for users with limited medical training.

II. PULSE OXIMETRY INTERPRETATION

In an effort to simplify the interpretation of pulse oximeter reading we have linked the SpO_2 sensor output to "Virtual Shunt" using a physiological model called oxygen cascade [6] or the representation of these relationship with a linearized measure called "Saturation Gap" [7]. These models not only facilitate physiological interpretation, but also include the well-known variability between oximeters and technical errors in estimation of SpO_2. This approach has shown to be also useful to address the challenge of SpO_2 interpretation at altitude [8]. During a randomize trial, over 12'000 pulse oximetry recordings from 300 healthy children living in rural Peru were obtained during the course of the year. The children were living at altitudes between 2000 m and 3800 m above sea level. In combination with the physiological model, these data allowed to establish the altitude-dependent normal SpO_2 range, which was previously not quantified.

This is an important step towards automated and real-time interpretation of SpO_2 signals in resource limited settings.

ACKNOWLEDGMENTS

We thank the Swiss – Peruvian Integrated Environment Health Development platform for data collection.

REFERENCES

[1] S. Crede, G. Van der Merwe, J. Hutchinson, D. Woods, W. Karlen, and J. Lawn, "Where do pulse oximeter probes break?," *J. Clin. Monit. Comput.*, vol. 28, no. 3, pp. 309–14, 2014.

[2] L. M. Funk *et al.*, "Global operating theatre distribution and pulse oximetry supply: an estimation from reported data," *Lancet*, vol. 6736, no. 10, pp. 1–9, Jul. 2010.

[3] J. Hudson *et al.*, "Usability testing of a prototype Phone Oximeter with healthcare providers in high- and low-medical resource environments," *Anaesthesia*, vol. 67, no. 9, pp. 957–67, 2012.

[4] W. Karlen *et al.*, "Human-centered phone oximeter interface design for the operating room: Pulse oximeter interfaced to a mobile device for anesthesia monitoring in the developing world," in *HEALTHINF 2011*, 2011.

[5] C. Petersen, T. Chen, J. Ansermino, and G. Dumont, "Design and Evaluation of a Low-Cost Smartphone Pulse Oximeter," *Sensors*, vol. 13, no. 12, pp. 16882–93, Dec. 2013.

[6] W. Karlen, C. L. Petersen, G. A. Dumont, and J. M. Ansermino, "Variability in estimating shunt from single pulse oximetry measurements," *Physiol. Meas.*, vol. 36, no. 5, pp. 967–981, 2015.

[7] G. Zhou, W. Karlen, R. Brant, M. O. Wiens, and M. J. Ansermino, "The saturation gap: a simple transformation of oxygen saturation using virtual shunt," 2018.

[8] M. Moreo, L. Tüshaus, J. Zhang, S. M. Hartinger, D. Mäusezahl, and W. Karlen, "Physiologically driven, altitude-adaptive model for the interpretation of pediatric oxygen saturation at altitudes above 2000 m a . s . l .," 2018.