Research and Reviews: Journal of Clinical and Medical Case Studies

Case Study for Two Noninvasive Devices Measuring Hemoglobin

Feng Yannan*, Wang Deqing and Yu Yang

Department of Blood Transfusion, Chinese PLA General Hospital, Beijing, China

Case Study

Received date: 03/10/2017
Accepted date: 09/10/2017
Published date: 16/10/2017

***For Correspondence**

Feng Yannan, Department of Blood Transfusion, Chinese PLA General Hospital, Beijing, China, Tel: +861068182255.

E-mail: Dr.fengya@gmail.com

Keywords: Hemoglobin, Tensortip, MTX, Non-invasive, Cnoga Medical, Bio-parameters, Anemia, Blood, Blood bank, Radical - 7, Masimo

ABSTRACT

Objective: This test report focuses on the evaluation of two noninvasive CFDA approved devices, TensorTip MTX (Cnoga Medical Ltd., Caesarea, Israel) and Radical-7 Pulse CO-Oximeter (Masimo Corporation, Irvine, CA), as part of the exploration of selecting a noninvasive device to be used in the Blood Bank in the Chinese People's Liberation Army General Hospital, Beijing, China. The aim of the evaluation was to verify the accuracy of hemoglobin measurements of each device independently vs the hospital clinical laboratory reference.

Methods: The TensorTip MTX and Radical-7 noninvasive measurements were compared separately to the hospital's clinical hematology analyzer measurements, taken by venipuncture. The test cases for each comparison included at least 26 patients over the age of 18 from the Blood Bank.

Results: The study showed that there was no significant difference between the non-invasive TensorTip MTX and the invasive clinical laboratory reference ($P<0.05$, paired, two-tailed t-test) in contrast to the noninvasive Radical-7 which provided statistically different results compared to the same hospital reference.

Conclusion: The performance of the TensorTip MTX noninvasive device was found as sufficiently equivalent to the hospital's clinical laboratory reference. From a clinical point of view, the TensorTip MTX is an extremely useful device with far reaching implications for patients. It provides for the first time commercially available, fast and reliable measurements of hemoglobin in a totally noninvasive manner.

INTRODUCTION

Hemoglobin (HGB) is a protein confined in red blood cells, and it is responsible for the delivery of oxygen to the tissues [1]. HGB is usually measured as a part of the routine Complete Blood Count (CBC) test of blood samples. A CBC is a broad screening test used to check for various disorders related to the blood [2]. HGB is measured to detect a number of pathologies, most notably anemia and its associated morbidities. It is generally measured from venous or capillary blood samples, run on a hematology analyzer. Current methods for HGB measurements need access to blood (i.e., skin puncture) and they do not provide instant results. Due to these facts, HGB measurement is not available for home use. In addition, in a healthcare setting, blood extraction exposes medical professionals to risks associated with blood exposure.

Since the 1950's, hematology analyzers commonly use the cyanmethaemoglobin method to spectrophotometrically measure total HGB content [3,4]. Blood samples are drawn into a collection tube containing an anticoagulant such as Ethylenediaminetetraacetic Acid. Prior to the automated measurement process in the analyzer, the samples are labeled, bar-coded and processed in the laboratory. Patient's results are recorded in a Laboratory Information System. The results of the blood tests are supervised and abnormal variations, such as a drop in HGB, are flagged. If the technician suspects an error, measurements on the analyzer may be repeated. Patient's results help doctors decide on an adequate treatment. For example, low blood volume or anemia will probably be treated with medications or blood transfusion [5].

METHODS

The Blood bank of the Chinese People's Liberation Army General Hospital (commonly known as Hospital 301) explored the possibility of using noninvasive HGB monitoring devices. The test cases for each comparison included at least 26 patients (age>18) from the Blood Bank. The Radical-7 Pulse CO-Oximeter (Masimo Corporation, Irvine, CA) is an optical device that uses the principle of spectrophotometry to calculate HGB concentration. It consists light-emitting diodes and a photodetector placed across the measurement site, providing an estimate of HGB based on absorbance characteristics (according to the Radical-7 Operator's Manual). The TensorTip MTX (Cnoga Medical Ltd., Caesarea, Israel) is a device based on optical technology of real time color image sensor and uses four monochromatic light sources. The color image sensor in the TensorTip MTX provides temporal-spatial-color information for the calculation of the HGB levels and other bio-parameters [6-9]. The results from the noninvasive devices were compared to the hospital's clinical laboratory reference hematology analyzer, a Sysmex XN9000 (Jinan Sysmex Medical Electronics Co. Ltd., Shanghai, China). All measurements were performed by the Blood Bank's personnel according to the manufacturers' instructions, independently and without help or participation of the manufacturers' representatives. The calculations used in the results are shown in Appendix A.

RESULTS

Blood samples were extracted for HGB measurements by the hospital's clinical laboratory reference, in parallel to the noninvasive measurements.

As shown in **Table 1**, the mean absolute difference between the TensorTip MTX and the reference is 0.99 g/dL. The relative mean positive and negative differences are 0.51 g/dL and -0.49 g/dL, respectively, indicating balanced measurements around the reference. The positive diffusion is 0.56 and the negative diffusion is 0.44, giving a quite symmetrical diffusion around the reference. The p-value (determined by paired, two tailed t-test) for the comparison between the TensorTip MTX and the reference is 0.93, indicating that the measurements are not significantly different ($P>0.05$). The total mean of the TensorTip MTX measurements is 13.60 ± 1.41 g/dL while the total mean of the reference is 13.58 ± 1.43 g/dL, a negligible difference of 0.02.

For the Radical-7, as shown in **Table 2**, the mean absolute difference is 1.44 g/dL. The mean positive and negative differences are 0.10 g/dL and -1.35 g/dL, respectively, indicating unbalanced measurements around the reference. The positive diffusion is 0.12, while the negative diffusion is 0.88, demonstrating unequal diffusion around the reference. The p-value for the comparison between the Radical-7 and the reference is 4.77E-05, denoting a significant difference between the Radical-7 and the hospital reference ($P<0.05$). The total mean of Radical-7 is 12.04 ± 0.96 g/dL while the total mean of the reference is 13.29 ± 1.03 g/dL, resulting in a difference of 1.25g/dL which is a relatively large difference, above 1 g/dL (for all calculations, see **Appendix A**).

Table 1. Comparison between the TensorTip MTX and the hospital reference (n=total measurements; n_{pos}=number of measurements with positive difference; n_{neg}=number of measurements with negative difference).

	Mean absolute difference (n)	Relative mean positive difference (n_{pos})	Relative mean negative difference (n_{neg})
Mean difference (g/dL)	0.99 (71)	0.51 (40)	-0.49 (31)
Diffusion		0.56	0.44
		TensorTip MTX	**Reference**
Mean ± SD [g/dL]		13.60 ± 1.41	13.58 ± 1.43
p-value		0.93	

Table 2. Comparison between the Radical-7 and the hospital reference.

	Mean absolute difference (n)	Relative mean positive difference (n_{pos})	Relative mean negative difference (n_{neg})
Mean difference (g/dL)	1.44 (26)	0.10 (3)	-1.35 (23)
Diffusion		0.12	0.88
		Radical-7	**Reference**
Mean ± SD (g/dL)		12.04 ± 0.96	13.29 ± 1.03
p-value		4.77 E-05	

Figures 1 and 2 visualize the comparisons between the noninvasive HGB results and the hospital reference. As we can see, the curves of the TensorTip MTX and the lab reference are almost overlapping **(Figure 1)** while the curves of the Radical-7 device and the lab reference are different **(Figure 2)**.

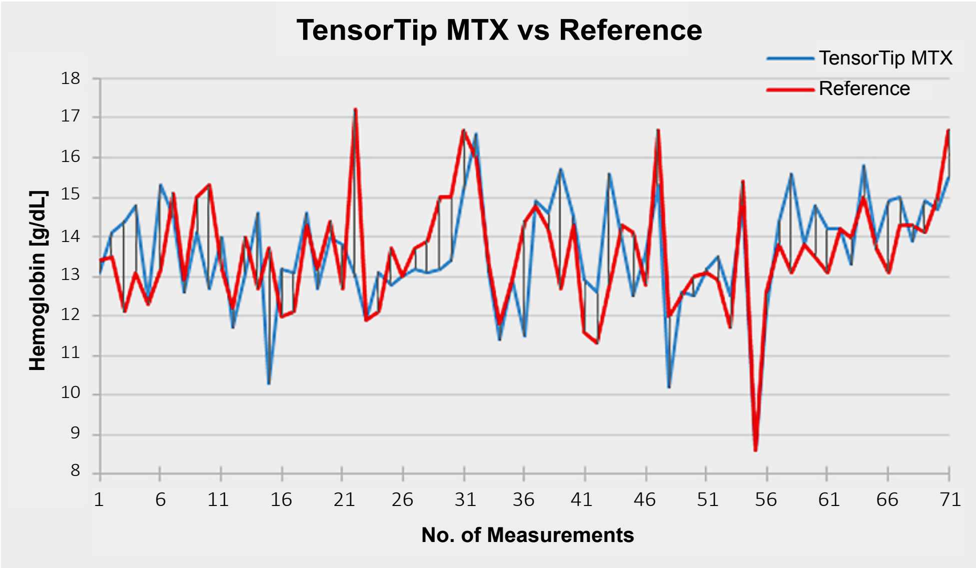

Figure 1. Paired samples of the TensorTip MTX HGB measurements and the hospital reference.

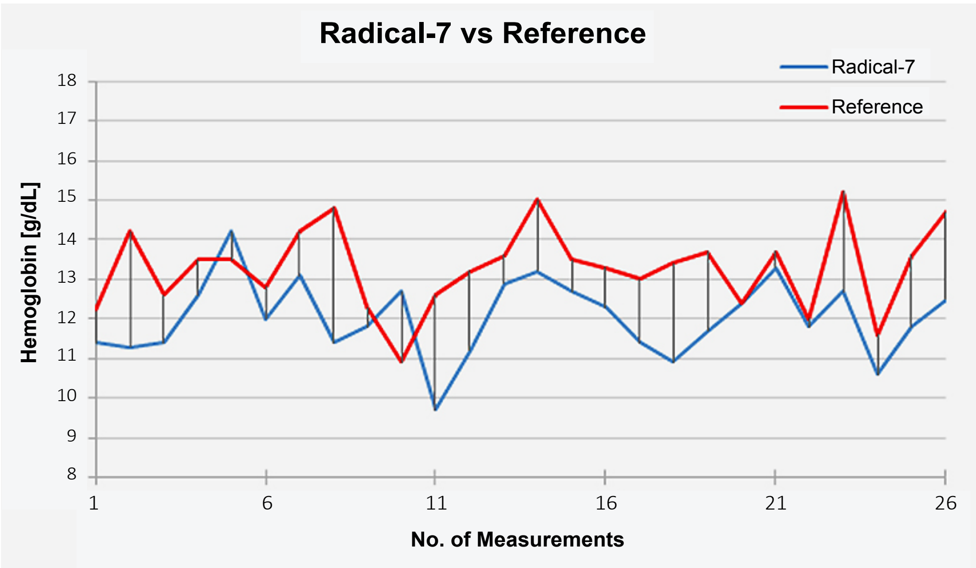

Figure 2. Paired samples of the Radical-7 HGB measurements and the hospital reference.

DISCUSSION

To date, most of peer-reviewed publications of noninvasive HGB measurements assessed the same technology of multi-wavelength pulse CO-Oximeters, namely the Radical-7. Previous study published in 2010 showed that the mean absolute difference of 97% of the noninvasive measurements was <2.0 g/dL [10]. Later study published in 2014, displayed a mean absolute difference of 1.2 g/dL [11].

In this study we evaluated the performance and accuracy of two noninvasive devices, the TensorTip MTX and the previously studied Radical-7 Pulse CO-Oximeter. These measurements were compared to the laboratory reference device. The comparison between the TensorTip MTX and the lab reference gave a mean absolute difference of 0.99 g/dL while the Radical-7 provided a mean absolute difference of 1.44 g/dL. In addition, it was found that there was no statistical difference between the TensorTip MTX and the lab reference device measurements, while the Radical-7 was significantly different from the same reference.

Despite study limitations of low number of subjects, the TensorTip MTX introduces prediction accuracy suitable for effective and safe use of hemoglobin monitoring. Further studies with a larger number of participants including a group of volunteers with abnormal hemoglobin levels should be conducted.

CONCLUSION

In conclusion, according to previous studies and our evaluation test report, the TensorTip MTX device provides results with a better accuracy than the Radical-7, when compared to the hospital reference device. Even though these results are preliminary and further studies should be undertaken, we believe that the TensorTip MTX represents a major step forward in facilitating patients' life and can be used as a point of care for individuals in their comfort home as well as for clinics.

APPENDIX A:

$Mean = \frac{\sum_{i=1}^{n} |MTX_i (or\ Rad7_i\ or\ \mathrm{Ref_i})|}{n}$ where (n=number of measurements, MTX=TensorTip MTX, Rad7=Radical-7, Ref=Reference)

$$Mean\ absolute\ difference = \frac{\sum_{i=1}^{n} |MTX_i (or\ Rad7_i) - \mathrm{Ref_i}|}{n}$$

$$Relative\ mean\ positive\ difference = \frac{\sum_{i=1}^{n} \ (MTX_i (or\ Rad7_i) - \mathrm{Ref_i}) \geq 0}{n}$$

$$Relative\ mean\ negative\ difference = \frac{\sum_{i=1}^{n} \ (MTX_i (or\ Rad7_i) - \mathrm{Ref_i}) < 0}{n}$$

$$Positive\ diffusion = \frac{Total\ measurements\ with\ positive\ difference}{Total\ participants}$$

$$Negative\ diffusion = \frac{Total\ measurements\ with\ negative\ difference}{Total\ participants}$$

REFERENCES

1. Wilbur D, et al. Clinical methods: the history, physical and laboratory examinations. Butterworths. 1990.
2. Dixon LR. The complete blood count: physiologic basis and clinical usage. J Perinat Neonatal Nurs. 1997;11:1-18.
3. Frank C, et al. Comparison of potential higher order reference methods for total haemoglobin quantification-an interlaboratory study. Anal Bioanal Chem. 2017;409:2341–2351.
4. L. Theodorsen. Haemoglobinometry on automated haematology analysers. Clin Lab Haematol. 1987;9:377-385.
5. Bain BJ, Bates I, Laffan MA, and Lewis SM, Dacie and Lewis practical haematology. Churchill Livingstone.
6. Segman Y. Optical sensor device and image processing unit for measuring chemical concentrations chemical saturations and biophysical parameters. 2006.
7. Segman Y. Finger deployed device for measuring blood and physiological characteristics. 2008.
8. Segman Y. Apparatus for obtaining and electronically interpreting digital images of liquids, solids and combinations on liquids and solids. 2004.
9. Segman Y. New Method for Computing Optical Hemodynamic Blood Pressure. J Clin Exp Cardiolog. 2016; 7:1-8.
10. Macknet MR, et al. The accuracy of non-invasive and continuous total hemoglobin measurement by pulse co-oximetry in human subjects undergoing hemodilution. Anesth Analg. 2010;111:1424-1426.
11. Dewhirst E, et al. Accuracy of non-invasive and continuous hemoglobin measurement by pulse co-oximetry during preoperative phlebotomy. J Intensive Care Med. 2014;29:238-242.