

**ORIGINAL RESEARCH**

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**Non-invasive method evaluation of hemoglobin levels after trauma****Emine Kadioglu<sup>1</sup>, Serhat Karaman<sup>2</sup>**<sup>1</sup>*Kutahya Health Sciences University, Medical Faculty, Department of Emergency Medicine, Kutahya, Turkey*<sup>2</sup>*Gaziosmanpasa University, Medical Faculty, Department of Emergency Medicine, Tokat, Turkey*

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**Abstract**

Continued invasive hemoglobin measurement has been performed by tools of pulse oximetry technology in recent years. Hemoglobin follow-up, especially in monitoring trauma patients, is essential in terms of the close watch of bleeding. We wanted in this study to evaluate the accuracy of such a tool in determining acute bleeding in patients who applied to emergency because of trauma. Patients who applied to emergency because of trauma were included in this study that was planned as prospective. Vital signs, laboratory hemoglobin values, and pulse hemoglobin values were synchronously recorded at 0, and 1, 2 st as from the moment they applied to the emergency department. 48 patients participated in the study. 60.4% of cases are seen in male participants. The reason for the general run of trauma was the applications arising from in-vehicle traffic accidents (n=24, 50%). There is no statistically significant difference in terms of the vital signs of patients during the follow-up. About the hemoglobin values that were taken during visiting and follow-up process of patients, there is a high level of significant correlation between averages of hemoglobin values and pulse hemoglobin values of patients in hourly follow-up ( $r_0=0.992$ ,  $r_1=0.997$ ,  $r_2=0.994$ ,  $p<0.001$ ). For this study findings, noninvasive hemoglobin measurement accuracy is an acceptable correlation between actual hemoglobin values and related device in evaluating acute bleeding in trauma patients.

**Keywords:** Pulse hemoglobin, blood loss, multitrauma patient, emergency department**Introduction**

Acute bleeding is a remarkable mortality and morbidity reason in acute bleeding trauma patients [1]. Although the available technological equipment in the emergency department and intensive care units, it may be difficult to determine bleedings in trauma patients in critical processes. Determination of bleeding and delays in interventions may cause disappointing results. These challenges in diagnostic mean may also encounter us as a delayed sequela of treatment. In spite of technological progress during the transfer of the critically ill patient to long distances; monitoring these patients limit with only the vital signs during transfer [1]. However, base deficit, lactate measurement, evaluation of coagulopathy and serial hemoglobin (Hbg) concentration measurement are used in addition to vital signs in evaluating acute bleeding, especially in trauma patients.

The most frequently used technique in determining Hbg concentration is the determination of photometric cyanmethemoglobin in a laboratory environment. This examination is the standard criterion that is also hematologically defined by international standardization committee [2,3]. Besides reliability, this analysis that is conducted as complete blood cell count (CBC) does not only give Hbg value but also provides extra diagnosis information such as the number of thrombocytes that can be beneficial to evaluate hemostasis in bleeding patient. Moreover, there are a few disadvantages to this multi-staged technique. Required time for performing procedures like taking a blood sample, transferring the samples to the laboratory, analysis of the sample, confirmation of results and data entry may retard diagnosis in critical trauma patients. Even taking repetitive sampling may cause anemia that contributes to transfusion especially in pediatric age group patients. In conclusion, there is a need for a laboratory environment and educated person to perform this examination. Accordingly, it is impossible to use it in transferring critical patients.

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On the other hand, it can be utilized in portable devices which use blood sample (10 milliliters) in small quantities for measuring

instant Hgb concentration. These devices show the result in time less than a minute. This practicality has popularized its use in critical care units such as emergency, newborn unit and operating room; however, this process also requires an invasive procedure. In addition to all these, there are studies which report that the accuracy rate of related devices varies by Hgb concentration [4-6].

A noninvasive spectrophotometry-based monitoring technology (Radical-7 Pulse CO-Oximeter; Masimo Corp., Irvine, CA) that provides Hgb measurement (SpHb) has been developed as the result of advancing technological advancements. This technique measures the differential optical density of light wavelength by a similar method to the digital pulse oximeter. Although the accuracy and benefit of noninvasive Hgb measurements via various devices have already been confirmed [7-10], only a few studies were conducted on patients with bleeding potential; different results were obtained as well [11-15]. Early determination of bleeding may contribute to performing proper resuscitation and improving the patient results if noninvasive Hgb measurement methods can be validated in trauma patients with bleeding potential. Therefore, the goal of this study was to compare the accuracy of noninvasive Hgb measurement (Radical-7) with invasive Hgb values (standard laboratory assessment) in trauma patients with bleeding risk.

## Material and Methods

Forty-eight adult patients (above 17 years) with high bleeding potential who applied to a tertiary training research hospital because of trauma were included in this research. Patients who voluntarily left the hospital or were transferred during the research period were excluded from the study. Required information and education were given clinic employees. Pulse oximeter method and FDA approved device called "Masimo Radical -7TM" that provides SpHb value measurement by the fingertip were utilized in this study to measure noninvasive Hgb concentration. A form was prepared to record the patients' information; the first controls when they applied to the emergency department were recorded as 0th hour. Age, gender, reasons for application, tension at 0-1st and 2nd hours, pulse, respiratory rate, oxygen saturation and noninvasive hemoglobin concentration values of cases were recorded in this form. The probe of noninvasive oximeter was placed on the first or second of finger distal tips of one hand during measurement. The probe was also placed on extremity across the probe which was placed for check the pulse and oxygen as far as possible. A lightproof plastic was placed between two devices to avoid the cross interaction of two probes when there was an urgency to settle both two probes on the same extremity. Hemoglobin values that could be read on the screen of the device were recorded on the patient form at the end of the process. Moreover, laboratory blood Hgb value was asked from simultaneous cases. Blood samples of patients were analyzed by "ADVIA 2120/2120i Hematology System" device in emergency biochemistry unit. All the values and outcome statuses of patients were recorded in data form.

## Results

Entirely 51 multiple trauma patients applied to an emergency during research. However, 3 patients who did not wait for service follow-up and were transferred to another hospital because of further examination and treatment were excluded from the research. Measurements of 48 patients were completed within

2011 September. Entirely 150 CBC and noninvasive hemoglobin measurement were performed at the same time (3 and 5 measurements per patient). 29 of the patients were male (60.4%); 19 of the patients were female (39.6%). Age average was found as  $40.19 \pm 14.73$  (min-max, 17-79).

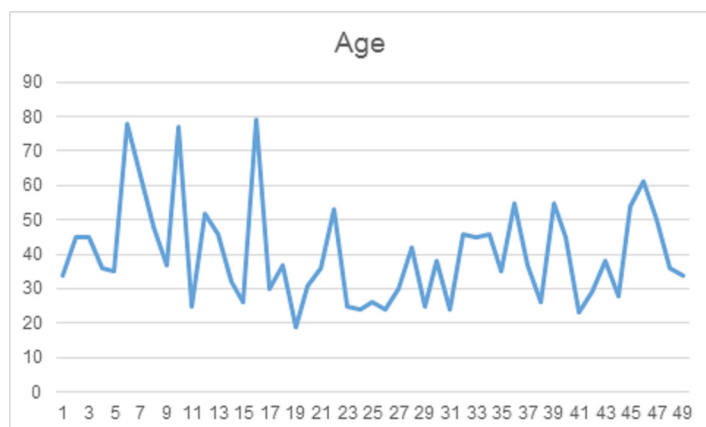
Figure 1 shows the age distribution of the facts. About the application complaints of cases in research, the general run of the cases consists of an in-vehicle traffic accident (n=24, 50%). Figure 2 detailedly shows the distribution of cases by application complaints. Change of systolic and diastolic blood pressure values at 0-1st and 2nd hours can be seen in Table 3. Both systolic and diastolic blood pressure values significantly decreased from 0th to the 1st hour ( $p < 0.00$ ); however, there was no significant difference between 1st and 2nd hours. There also was no pathology during the follow-up process when pulse and respiratory rates of patients were evaluated. Table 3 detailedly shows an average of pulse and respiratory rates. Figure 3 represents the change of averages of hemoglobin in blood and hemoglobin values measured by a pulse at 0-1st and 2nd hours. As is seen in this graphic, decrease in blood and hemoglobin values measured by pulse are parallel to each other. There is a high level of correlation between the averages of hemoglobin values in blood and hemoglobin values measured by a pulse ( $r_0 = 0.984$ ,  $r_1 = 0.997$ ,  $r_2 = 0.993$ ,  $p < 0.001$ ) (Table 2). It is seen when laboratory and noninvasive hemoglobin concentrations of patients are scrutinized that values that are measured by the device are lower than the laboratory values (Table 1). Hemoglobin value that was measured by a pulse at the 1st hour is found as significantly lower ( $t = 2.840$ ,  $p < 0.007$ ). Also, there is no significant difference between hemoglobin values in blood and the same values that were measured at the 2nd hour by a pulse ( $t = 1.992$ ,  $p < 0.052$ ). About whether the decrease in hemoglobin values is about other blood parameters show erythrocyte volume, there also is a decrease in hematocrit and average erythrocyte volume (MCV) of patients. It can be talked when the outcome statuses of patients are analyzed that 15 (31.3%) of them were hospitalized; others were discharged from the hospital after the follow-up of an emergency.

**Table 1. Monitoring of vital values and laboratory values of patients**

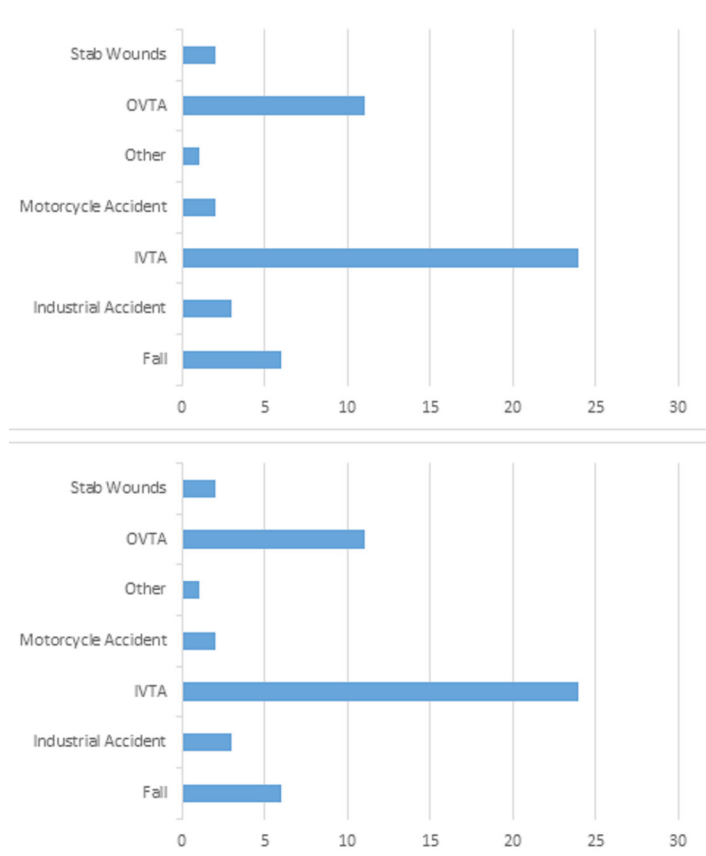
| Bulgular                        | 0. Hour | 1. Hour | 2. Hour | Min   | Max   |
|---------------------------------|---------|---------|---------|-------|-------|
| Pulse (n)                       | 83.31   | 82.71   | 82.33   | 60    | 126   |
| Respiration (/minute)           | 12.46   | 12.60   | 12.65   | 12    | 18    |
| Diastolic Blood Pressure (mmHg) | 76.15   | 72.82   | 70.83   | 50    | 100   |
| Systolic Blood Pressure (mmHg)  | 122.48  | 116.25  | 114.58  | 90    | 170   |
| Hematocrit (%)                  | 40.55   | 39.44   | 39.20   | 21.40 | 52.20 |
| MCV (fL)                        | 84.08   | 83.93   | 83.87   | 53.20 | 95    |
| Non-invasiv Hemoglobin          | 13.80   | 13.43   | 13.24   | 7.5   | 17.2  |
| Invasiv Hemoglobin              | 13.88   | 13.49   | 13.31   | 7.8   | 17.2  |

**Table 2. Correlation between non-invasive and invasive hemoglobin concentration**

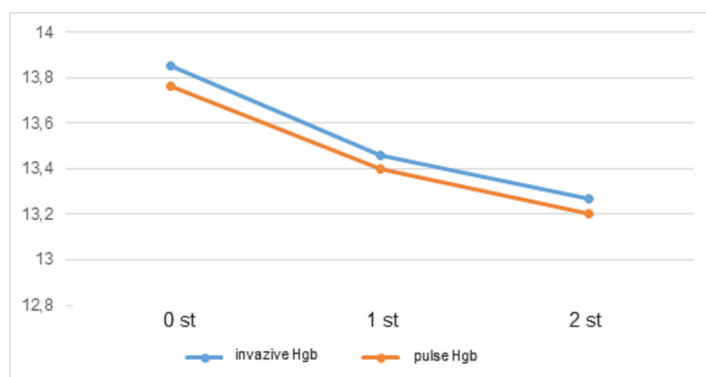
| Bulgular  | R (Spearman's) | p    |
|-----------|----------------|------|
| 0 st hour | 0.984          | 0.00 |
| 1 st hour | 0.997          | 0.00 |
| 2 st hour | 0.993          | 0.00 |



**Figure 1.** Age distribution of patients



**Figure 2.** Distribution of the causes of hospital admission to patients



**Figure 3.** Hemoglobin values measured in blood and pulse of patients

## Discussion

To determine bleeding in critically ill patients like trauma patients may be hard by clinical evaluation; especially serial Hbg measurement is the most acceptable method in follow-up the patients with bleeding risk [1]. Serum Hbg measurements may cause bloodlettings which can contribute anemia. Again, resulting in these laboratory tests may take much time and there also may occur delays in noticing and managing the acute bleeding.

Correct and reliable noninvasive Hbg measurement helps to notice bleeding in trauma patients. This study was designed to evaluate the correlation between standard laboratory values and Hbg concentration measured by Radical-7 in patients with bleeding risk. Again, contrary to previous studies which evaluated stable patients; using noninvasive Hbg measurement in critical trauma patients with bleeding risk shows us such devices can avail to available care standards and be utilized in critical care units.

The radical-7 device has already been examined in the intensive care unit and operating room [6,8,11]. Causey et al. conducted a study on the patients in the surgical and intensive care unit and found that noninvasive Hbg values are 0.5 g/dl between two groups [12]. Frasca's Radical-7 measurements found a much closer correlation between laboratory Hbg measurements ( $0.0 \pm 1.0$  g/dl) [9]. However, there was also found variables which endanger the clinical benefit of noninvasive Hbg follow-up. Another study compared Radical-7 and bed-side care devices. It was pointed out that the accuracy of Radical-7 devices is worse [16]. Gayat et al. compared the averages of laboratory Hbg concentrations and radical-7 measurements and determined that values of Radical-7 are lower by 1.59 g/dl than the laboratory values. Moreover, noninvasive Hbg value could not be taken in 8% of geriatric patients with low diastolic blood pressure, CBC and Spo2 [10].

In this study, there was found a serious correlation between laboratory Hbg values and noninvasive Hbg values of Radical-7 in multiple trauma patients with bleeding risk ( $p < 0.00$ ). However, there was found a difference between noninvasive Hbg values at the time of first appeal and noninvasive Hbg values at the 1st and 2nd hours. The reason for this circumstance maybe since the Radical 7 monitor uses spectrophotometric-based technology by analyzing light transmission through tissue, any environment and/or patient factor may have a potential to change the read. It has not been defined how the accuracy of the Radical-7 device affects the factors like low arterial perfusion, low oxygen saturation, high bilirubin, and severe anemia. There is a need for performing multiple subgroup analysis to evaluate these factors.

Our study has not found a significant difference in terms of arterial blood pressure and oxygen saturation of the patients. Accordingly, the high correlation between the two techniques may arise from the homogenized distribution of values within the patient group.

Noninvasive Hbg measurements may not give correct results in patients with severe anemia. For literature, noninvasive Hbg values which are measured by Radical-7 show truer results in patients whose CBC is over 8 g/dl [17-18]. The lowest hemoglobin value was found as 7.2 g/dl in our study. This situation explains the reason for the high correlation between the two techniques.

Serial Hbg measurements rather than absolute Hbg concentration are used to evaluate the bleeding or response after transfusion [1]. We analyzed the properness of changes in serial noninvasive Hbg measurements to laboratory Hbg measurements. We found at the end of the analyses that there is a significant correlation between invasive and noninvasive measurements.

Different results have been obtained in similar studies on trauma patients. There was revealed a low correlation in severe trauma patients [19].

Since there was no patient with serious acute bleeding and hemoglobin value under 8, we have not observed such a result. Studies which have been conducted on postoperative patients found similar correlation coefficients to ours.

### Limitations

However, our research has also some restrictions. Definitions during creating standards are essential. Accordingly, since there is no definition for a standard device, our definition was compared with the accuracy rate in similar studies.

### Conclusions

In conclusion, pulse Hbg monitorization can help diagnose silent bleeding in trauma patients when it is combined with clinical evaluation. It is quick, bedside, noninvasive and ease technique; these factors are valuable in terms of friendliness. Similar technologies which provide us to gain ground in terms of both cost and time are vital when we evaluate the conditions in terms of the working conditions of emergency. There is a need for more comprehensive studies in terms of the reliability of data.

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### Conflict of interest

*The authors declare that there are no conflicts of interest.*

### Financial Disclosure

*All authors declare no financial support.*

### Ethical approval

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