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# NON-INVASIVE METHOD USED TO DETECT HAEMOGLOBIN WITH SYMPTOMS BASED RECOVERY SYSTEM

[1]SYED ALTHAF S, [2]BRUNDHA M, [3]KARTHIKA S, [4]MAHALAKSHMI K, [5]THARINI M

[1]Assistant Professor, Bio Medical Engineering,SALEM COLLEGE OF ENGINEERING AND TECHNOLOGY, INDIA-636 111.
[2,3,4,5]UG scholar, Bio Medical Engineering,SALEM COLLEGE OF ENGINEERING AND TECHNOLOGY, INDIA-636 111

**ABSRACT**

Technology has transformed the practice of medicine and surgery in particular over the last several decades. This change in practice has allowed diagnostic and therapeutic tests to be performed less invasively. Haemoglobin monitoring remains one of the most commonly performed diagnostic tests in the United States Recently, non-invasive haemoglobin monitoring technology has gained popularity. The aim of this article is to review the principles of how this technology works, pros and cons, and the implications of non-invasive hemoglobin technology particularly in trauma surgery. In Proposed system we not only detect the non-invasive hemoglobin levels but we also compare other symptoms like respiration, pulse rate and fits detection during surgery and provide oxygen if the patient loses his breath count.

**KEYWORDS**: Haemoglobin Measurement, Fits Detection, Air Flow Sensor, Pulse Sensor

## 1. INTRODUCTION

Technology has transformed the practice of medicine and surgery in particular over the last several decades. This change in practice has allowed diagnostic and therapeutic tests to be performed less invasively. Haemoglobin monitoring remains one of the most commonly performed diagnostic tests in the United States. Recently, non-invasive haemoglobin monitoring technology has gained popularity. The aim of this article is to review the principles of how this technology works, pros and cons, and the implications of non-invasive haemoglobin technology particularly in trauma surgery.

Technology has always been an essential component of patient care. As technology has advanced over the years, the way we have practiced medicine has evolved as well. Perhaps no field in medicine has been affected by technology as much as surgery. From operations being performed without any pain control to robotic surgery, technology has completely revamped our practice of surgical care and the field of trauma surgery and critical care remains no exception.

One of the major influences of technology on patient care has been the shift in paradigm away from highly invasive diagnostic and therapeutic procedures to non-invasive procedures. This has resulted in reduced time to diagnosis, critical decisions making, and treatment as well as improved patient satisfaction. Haemoglobin measurement is one of the most frequently performed laboratory tests after injury Non-invasive haemoglobin monitoring is a more recent introduction to the growing list of point-of-care testing capabilities that allows for the ability to monitor haemoglobin concentration in a continuous, accurate, and non-invasive fashion It is still growing in popularity and it is our impression that many trauma and critical care providers do not know about its utility nor the basic principles behind the mechanism of function. In this review, we will briefly discuss the basic principles of how non-invasive haemoglobin monitoring technology works, the different factors that affect its accuracy, and demonstrates how this technology may translate into added benefits to patient care.

**Haemoglobin measurement**

Invasive measurement, although accurate is time-consuming, costly, painful for the patient, and may have potential risk for exposure to biohazards. It can significantly delay patient care because of the time required for the phlebotomy, transport of the sample to the laboratory, time required for analysis and validation, and the reporting of results back to physician. Haemoglobin (Hgb) measurement is one of the most frequently ordered laboratory tests in the trauma settings; it can help guide therapeutic plan of management In trauma patients, these decisions range from blood transfusions to operative intervention. There has been a significant paradigm shift towards non-operative management in trauma patients and the rate of operative intervention in blunt abdominal and pelvic trauma has significantly declined. The majority of these patients are managed non-operatively and undergo surgical intervention only for on-going bleeding or hemodynamic instability This approach however requires close monitoring in the Intensive Care Unit (ICU) and repeated phlebotomy for haemoglobin measurement to assess for on-goinghaemorrhage The use of continuous or spot-check non-invasive haemoglobin monitoring provides the ability to monitor these patients in real time and react to changes in haemoglobin levels. A Cochrane review from ten trials reported outcomes on 1780 patients and found that a restrictive transfusion strategy is associated with 20% lower mortality, reduced hospital and ICU length of stay [6]. On the other hand, post operative anemia is also associated with increased post operative morbidity and mortalit Accurate continuous measures of haemoglobin can help avoid the extremes of over or under transfusion. This is another avenue where a quick non-invasive measurement of haemoglobin can help in the implementation of restrictive transfusion strategy.

## 2. BASICS OF FUNCTION

There is some variation in the basic principles that govern the functioning of most commercially available non-invasive devices. Most non-invasive haemoglobin measurement devices rely on spectrophotometry. Light is transmitted through or reflected from tissues and blood differentially depending on their biochemical variables. This difference in the degree of reflection allows for calculation of the haemoglobin and haematocrit using a mathematical model

Other devices rely on photoplethsmography, which is the study of volume changes in the body. They detect the relative magnitude of the photoplethysmographic signal at different times of the cardiac cycle using different wavelengths of light. Separate photo-detectors detect this signal and utilize it to determine the haemoglobin content and haematocrit of blood.

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**3. Non-invasive haemoglobin monitors**

Masimo Corporation (Irvine Ca.) has developed a Pulse CO-Oximetry capable of measuring haemoglobin concentration using a non-invasive, multi-wavelength sensor for spot check and continuous measurement: the Radical 7 (Rad7) The technology emits multiple wavelengths of light and then calculates the haemoglobin concentration based on the adsorption of light in the blood The device uses a finger tip probe similar to a standard pulse Oximetry sensor and determines suggests, monitors serum haemoglobin continuously and provides real time haemoglobin levels similar to how a pulse Oximetry provides continuous oxygen saturation. The spot check haemoglobin monitor works by the same principle as the continuous monitor but is a point-of-care device that calculates the serum haemoglobin level within 1 min of placement of the probe. The accuracy and reliability of both these monitors vary and the clinical applicability in trauma remains to be defined.

**4. Accuracy of continuous non-invasive haemoglobin monitoring**

The first study to look at the accuracy of Rad-7 non-invasive haemoglobin measurement was performed by Mack net et al., and enrolled twenty-eight subjects (included 19 patients who underwent surgery and 9 healthy volunteers who underwent a hemodilution protocol Subjects underwent phlebotomy of 450 cc of blood which was subsequently replaced with normal saline. The haemoglobin measurements in subjects undergoing hemodilution and patients undergoing surgery were monitored with laboratory CO-Oximeter and data points were compared with those measured by Rad-7. Using 458 data pairs, the authors demonstrated a very strong correlation coefficient of 0.90

The same group performed another validation study for continuous haemoglobin monitoring using the hemodilution model in healthy subjects. In 335 paired observations, they found excellent correlation between non-invasive haemoglobin measurement when compared to invasive haemoglobin measurement. They concluded that continuous haemoglobin monitoring was accurate to within 1 g/dL (1 SD) compared to laboratory measures of haemoglobin

The above cited studies were proof of concept studies and were performed on healthy subjects. The accuracy and utility of continuous non-invasive haemoglobin measurement were next tested on real patients in clinical settings. This merits discussion, as the accuracy of the device may vary under different clinical settings.

Physicians caring for ICU patients rely heavily on swift and accurate haemoglobin measurements for making clinical decisions. A prospective observational study of sixty-two ICU patients with continuous non-invasive haemoglobin monitoring found excellent correlation and accuracy, expressed as ARMS value between 0.5 and 1.4 g/dL between the measures of non-invasive and invasive methods of haemoglobin measurement . The bias and limits of agreement were also within the traditionally acceptable limits of 0.0 ± 1.0 g/dL. Interestingly, despite the fact that 34% of patients were on continuous nor-epinephrine (that may potentially decrease the peripheral perfusion) excellent correlation was found between continuous non-invasive and invasive haemoglobin measurement.

**3. PULSE SENSOR**

Pulse Sensor is a well-designed plug-and-play heart-rate sensor for Arduino. It can be used by

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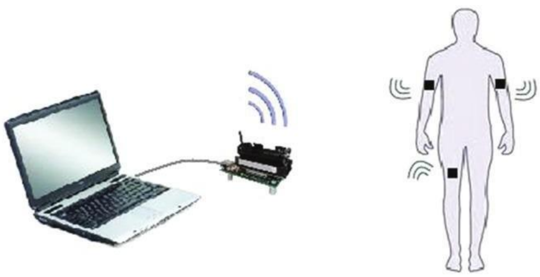
students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart rate data into their projects. The sensor clips onto a fingertip or earlobe and plugs right into Arduino with some jumper cables. It also includes an open-source monitoring app that graphs your pulse in real time. Heart rate data can be really useful whether you're designing an exercise routine, studying your activity or anxiety levels or just want your shirt to blink with your heart beat. The problem is that data into their projects. It essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable pulse readings. Also, it sips power with just 4mA current draw at 5V so it's great for mobile applications.

**Fits Detection**

The monitoring of epileptic seizures is mainly done by means of electroencephalogram (EEG) monitoring. Although this method is accurate, it is not comfortable for the patient as the EEG-electrodes have to be attached to the scalp which hampers the patient's movement. This makes long-term home monitoring not feasible. In this paper, the aim is to propose a seizure detection system based on accelerometry for the detection of epileptic seizure.



Proposed system for epileptic seizure detection

**Data Collecting**

Datasets from patients suffering from heavy epilepsy were used for the development of an automatic detection algorithm. In this system, three 2D accelerometer sensors were positioned on the right arm, left arm and left thigh of epileptic patients. Datasets were acquired from three patients suffering from severe epilepsy. The datasets of the epileptic patients were recorded during the day. We recorded 20 epileptic seizures.

Patients were asked to perform a sequence of everyday normal activities but were not told specially how to do them. Normal activities that we recorded included static activities such as reading, working with computer, brushing of teeth, and lying and dynamic activities such as walking. The sampling frequency of the accelerometer is 3 Hz. Figure 2 shows the pure output of accelerometers when sampling frequency is 3 Hz. It shows at first lying and then seizure signal. In this Figure the seizure has begun from 180 samples. Acceleration has been measured based on gravity ($g=9.8m/s^2$)

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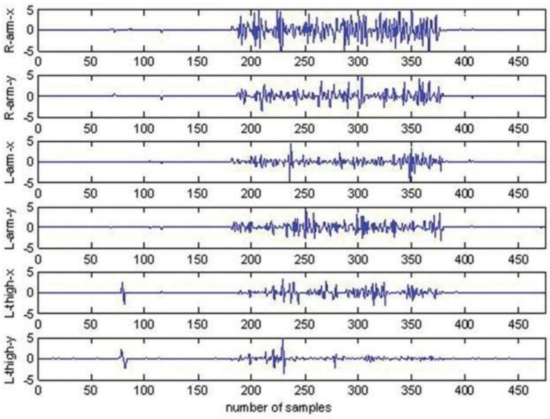



**Preprocessing**

The output of an accelerometer attached to the human body consists of different components:

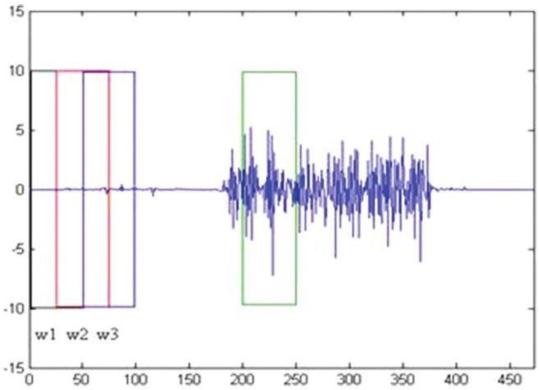
a. Noise from sensor and measurement system

b. Noise sources from the environment: (a) accelerations produced by external sources like vehicles; (b) accelerations due to bumping of the sensor or the body against other objects

c. Noise sources from the body: (a) Muscle tremor; (b) Heart; (c) Respiration; (d) Blood flow

d. Gravitational acceleration

e. Acceleration due to movements of the body



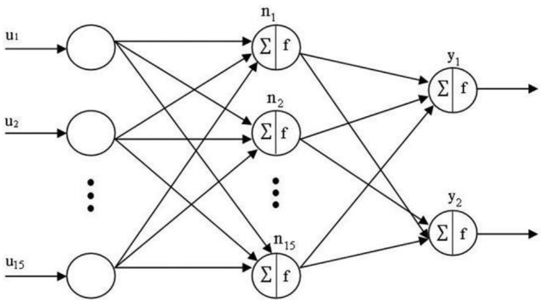

In comparison to body movements, the noise from the sensor and measurement system can be neglected. All data used in this study were recorded while the patients were in their living environment, thus there were no accelerations produced by external sources.

When there is no movement, physiological perturbations, like respiration and heart rate and gravitational acceleration are visible in the signal. A preprocessing step is executed on the raw data for deleting these perturbations. To do that, we use a moving average filter. If the received signal is denoted as X(k), the filtered signal is given by following equation:

$$X_s(k) = X(k) - \frac{\sum_{l=-L}^{L} X(k+1)}{2L+1}$$

Where $X_S(k)$ is the output of the filter.

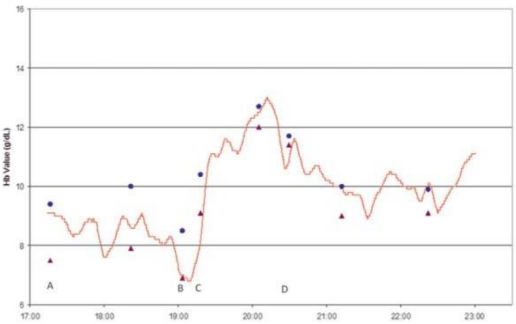
2 L + 1 is the size of the sliding window expressed in the number of samples, the filter length.
We introduce a delay of LT in the flow of data. In practice T = 1/3,
so for L = 2, the delay is 0.6 seconds.




## 4. PULSE OXIMETRY

Pulse oximetry, invented by Takuo Aoyagi of Nihon Kohden in 1974, was originally limited in clinical adoption because of concerns about accuracy in oxygen saturation (SpO2).6 Early studies during normoxia showed SpO2 differences of ≥6% compared with arterial blood analyzed on CO-Oximeters (SaO2), 7 differences of 10% to 20% during hypoxia, 8 and known signal dropouts and inaccuracy during low perfusion and motion. Despite these accuracy limitations, pulse oximetry became a "standard of care" by the late 1980s. This was partly due to the fact that even when pulse Oximetry SpO2 measurements varied widely from the CO-Oximeter values, changes in SpO2 "appeared to reflect changes in saturation accurately in the same patient."9 In their 1989 review article, Tremper and Barker10 noted that the pulse oximeter was "one of the most important advances in non-invasive monitoring because it provides a means of continuously and quickly assessing oxygen saturation." More than 20 years later, Severinghaus6 noted that the "Introduction of pulse oximetry coincided with a 90% reduction in anesthesia-related fatalities."

The contribution of pulse oximetry to improvements in patient safety was not because its non-invasive measurements replaced invasive laboratory measurements. Rather, as was emphasized back in 1989, it was the continuous and real-time properties of pulse oximetry that were so central to this new paradigm of patient monitoring. With continuous SpO2 monitoring, clinicians became aware that oxygen saturation was decreasing when the patient otherwise appeared to be well oxygenated. Continuous SpO2 monitoring also provided non-invasive reassurance that arterial blood was oxygen saturated when other means of clinical assessment were not helpful. Using this monitor as part of routine patient care allowed the clinician to focus on other aspects of management.




haemoglobin measurements

**CONCLUSION**

The results from evaluations of real time continuous haemoglobin measurement with Pulse CO-Oximetry are promising. In many settings real time continuous haemoglobin measurements appear has been improve with accuracy as capillary haemoglobin determination when compared to laboratory analysis. Nevertheless, there is room for improvement of the technology (which is on-going), for educating clinician on the best use of the technology and adapting clinical pathways to take advantage of this new tool. In the author's eyes, because the technology is not intended to replace laboratory measurements, it is less important to receive a measurement that exactly mirrors a laboratory value, rather than to provide continuous information regarding the changes or stability of haemoglobin. For the spot check applications, the immediacy of data and non-invasive nature of the device make it ideal for pre-hospital triage decisions such as choosing the right hospital. At the hospital, this technology has the potential to assist emergency department staff in making triage priorities and in assigning staff and infrastructure. The ease of use of these devices allows for the universal screening of all presenting patients for anaemia which could indicate occult bleeding or other disease processes requiring intervention.

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