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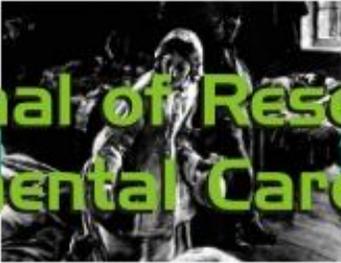
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## INTEGRATIVE REVIEW OF THE LITERATURE

O uso do oxímetro de pulso na avaliação hemodinâmica

The use of pulse oximeter in hemodynamic assessment

El uso de oxímetro de pulso en la evaluación hemodinámica

Luciana Mendonça Pereira <sup>1</sup>, Renata Flávia Abreu <sup>2</sup>, Priscilla Max <sup>3</sup>

### ABSTRACT

**Objective:** Identify and analyze the scientific literature on pulse oximeter with plethysmograph for assessing hemodynamic perfusion. **Method:** this is an integrative literature review, conducted in January and February 2012 on the Virtual Health Library. Studies published from 2000 to 2011 were selected. **Results:** after evaluating titles, 24 articles were selected for reading of the abstracts; 17 articles were excluded for not addressing the issue at stake, something which resulted in the inclusion of 7 articles in the sample. **Conclusion:** nursing care and multidisciplinary team care for the patient using pulse oximeter with plethysmograph may associate non-invasive parameters for hemodynamic assessment of perfusion in everyday clinical practice. **Descriptors:** Oximetry, Perfusion, Hemodynamics, Nursing.

### RESUMO

**Objetivo:** Identificar e analisar a produção científica sobre o oxímetro de pulso com pletismógrafo para avaliação da hemodinâmica da perfusão. **Método:** trata-se de revisão integrativa de literatura, desenvolvida em janeiro a fevereiro de 2012 na Biblioteca Virtual da Saúde. Foram selecionados estudos publicados de 2000 a 2011. **Resultados:** após avaliação dos títulos, foram selecionados 24 artigos para leitura dos resumos; 17 artigos foram excluídos por não abordar a temática em questão, o que resultou na inclusão de 7 artigos na amostra. **Conclusão:** os cuidados de enfermagem e da equipe multiprofissional ao paciente em uso do oxímetro de pulso com pletismógrafo podem associar parâmetros não invasivos para a avaliação hemodinâmica da perfusão na prática clínica cotidiana. **Descritores:** Oximetria, Perfusion, Hemodinâmica, Enfermagem.

### RESUMEN

**Objetivo:** Identificar y analizar la literatura científica acerca de oxímetro de pulso con pletismógrafo para evaluar la perfusión hemodinámica. **Método:** esta es una revisión integradora de la literatura, llevada a cabo en enero y febrero de 2012 en la Biblioteca Virtual en Salud. Se seleccionaron estudios publicados de 2000 a 2011. **Resultados:** después de evaluar los títulos, se seleccionaron 24 artículos para la lectura de los resúmenes; 17 artículos fueron excluidos por no abordar el tema en cuestión, lo que resultó en la inclusión de 7 artículos en la muestra. **Conclusión:** los cuidados de enfermería y del equipo multidisciplinario al paciente que utiliza oxímetro de pulso con pletismógrafo pueden asociar parámetros no invasivos para la evaluación hemodinámica de la perfusión en la práctica clínica cotidiana. **Descriptor:** Oximetría, Perfusion, Hemodinámica, Enfermería.

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## INTRODUCTION

**T**his study was motivated by a notification received by the risk management of a federal hospital, specialized in high-complexity cardiology, located in the city of Rio de Janeiro, Brazil. The focus of this notification was an arterial vascular complication after a hemodynamic procedure.

Pulse oximeter with plethysmograph was used to monitor a vascular complication, requiring a continuous assessment of peripheral perfusion to avoid aggravation. The plethysmograph was used to assess pulse amplitude for a safe and effective treatment until surgical intervention.

Pulse oximeter with plethysmograph consists in measuring peripheral oxygen saturation continuously and noninvasively, with a reliability of 99.4% when compared to arterial oxygen saturation. It uses techniques based on the principles of plethysmograph, which determines pulse amplitude and pulse waveform, and spectrophotometry, which analyzes light transmission through tissue.<sup>1</sup>

Studies in recent years have shown plethysmograph as a way to assess peripheral perfusion, as it enables the determination of pulse amplitude and pulse waveform. Taking into account that a technology used in everyday respiratory monitoring of the critically ill patient is pulse oximeter, it has been cogitated to associate it to hemodynamic monitoring, since its functioning is based on plethysmograph, and this, consequently, might enable perfusion evaluation.<sup>1</sup>

Pulse oximeters with plethysmograph have on their display the indicator of pulse amplitude in the form of pulse wave or beep bar, which show the results obtained by light-emitting diode (LED) which emits red and infrared light.

When installed on a surface with good blood flow, they promote the passage of light, which will be more or less absorbed, depending on the amount of saturated and reduced hemoglobin observed in the area.<sup>2</sup>

Based on the need to determine pulse for respiratory monitoring through oxygen saturation, we may think of using pulse oximetry to monitor peripheral perfusion, during and after procedures or even during nursing care.

Given the above, the following question emerged: “Can pulse oximeter with plethysmograph be used in clinical practice to monitor hemodynamic perfusion?”

Based on this question, this study investigates the scientific literature on the theme.

The study is justified by the need of increasing knowledge about the use of pulse oximetry to monitor perfusion, since it was designed as a complement to respiratory assessment. We may propose using the digital plethysmograph contained in pulse oximeter, an example of the technological advance that enabled creating and improving various resources in order to facilitate diagnosis, improve the procedures performed, and anticipate complications, thus providing a better patient care.<sup>2</sup>

This study aims to contribute to the knowledge basis about hemodynamic monitoring, with a view to promote the use of the technology under analysis by the nursing team dealing with hospitalized patients.

## METHOD

This is an integrative literature review; to conduct it, we followed the six phases described by Pompeo, Rossi, and Galvão: identifying the theme or question; sampling or literature search; categorization of studies; assessment of studies included in review; interpretation of results; and synthesis of knowledge evidenced in the articles analyzed.<sup>3</sup>

The choice of this method was due to the fact that it constitutes a comprehensive approach, allowing the inclusion of experimental and non-experimental studies. It has been pointed out as a unique tool in the health field, for summarizing the available researches on a particular subject and guiding the practice, which is grounded in scientific knowledge.<sup>3</sup>

For choosing descriptors, a survey was conducted on the Virtual Health Library (VHL), on the database named Descriptors in Health Sciences (DeCS); through the keywords identified, we selected the terms “pulse oximetry” and “perfusion”.

The terms related to nursing care, such as “nursing” and “hemodynamics”, were not used as descriptors, since their inclusion in the search field reduced to zero the selection of articles.

We included original articles published in journals indexed by the databases National Library of Medicine (MEDLINE) and Latin American and Caribbean Literature in Health Sciences (LILACS) addressing the theme. We excluded the studies found in more than one database. We selected articles in Portuguese, English, and Spanish published from 2000 to 2011. Searches were conducted in January and February 2012. The sources were located by means of the website of journals of the Coordination for the Improvement of Higher Education Personnel (CAPES).

## RESULTS E DISCUSSION

Initially, 160 articles were identified in the database MEDLINE and 2 articles in the database LILACS. To refine the search, the time limit from 2000 to 2011 was applied, remaining 122 articles. After reading their titles, 21 articles in English, 1 article in Portuguese, and 2 articles in Spanish were selected, totaling 24 articles for reading of abstracts.

After reading of abstracts, 17 articles were excluded, as they did not address the

theme, remaining 7 articles, which were selected for full reading. The final selection of articles is shown in Box 1.

**Box 1** - Articles selected for analysis.

| Year | Journal             | Authors                                                                                       | Title                                                                                                                           |
|------|---------------------|-----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| 2000 | Rev Mex Anesthesiol | Romo Salas F, Aguilera Morales AAJ, Hernández Sierra F, Noyola Frías MA, Martínez Bañuelos J. | Allen test with pulse oximetry for the cannulation of radial or cubital artery in anesthetized patients.                        |
| 2006 | J Med Eng Technol   | Foo JY, Wilson SJ.                                                                            | Detection method to minimize variability in photoplethysmographic signals for timing-related measurement.                       |
| 2007 | J Clin Monit Comput | Yang S, Batchelder PB, Raley DM.                                                              | Effects of tissue outside of arterial blood vessels in pulse oximetry: A model of two-dimensional pulsation.                    |
| 2008 | Anesthesiology      | Reisner A, Shaltis PA, McCombie D, Asada HH.                                                  | Utility of the photoplethysmogram in circulatory monitoring.                                                                    |
| 2010 | J Clin Monit Comput | Umesh G, Jasvinder K, Nanda S, Ranjan S.                                                      | Arterial line for monitoring SPO2 in patients with ischemic peripheries.                                                        |
| 2010 | Anesthesiology      | Taenzer AH, Pyke JB, McGrath SP, Blike GT.                                                    | Impact of pulse oximetry surveillance on rescue events and intensive care unit transfers: a before-and-after concurrence study. |
| 2011 | Curr Opin Crit Care | Middleton PM, Davies SR.                                                                      | Noninvasive hemodynamic monitoring in the emergency department.                                                                 |

Out of the total of 7 articles addressing the theme use of pulse oximeter with plethysmograph in clinical practice for hemodynamic monitoring of infusion, 2 are case-control studies, 2 are cross-sectional studies, and 3 are literature reviews. Box 2 summarizes data from these studies.

**Box 2** - Characteristics of articles identifying the use of pulse oximeter with plethysmograph to assess perfusion.

| Article                                                                                                   | Study type        | Results/conclusions                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Allen test with pulse oximetry for the cannulation of radial or cubital artery in anesthetized patients.  | Case control      | There was no significant difference between pulse oximetry for radial or ulnar artery cannulation. It is concluded that the simplicity of the technique described and the wide availability of an oximeter in the operating room make the assessment useful and valid in anesthetized or unconscious patients. |
| Detection method to minimize variability in photoplethysmographic signals for timing-related measurement. | Literature review | A minimal variation in phase characteristics has shown to be critical to achieve an accurate estimate of time related to measurements, such as heart rate and pulse. When investigating abnormal variations in the configurations of detection of the                                                          |

|                                                                                                                                 |                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                 |                   | various forms used in plethysmographic signals, it is found out that such configurations are still unsuitable for clinical interpretation of the physiological blood flow time.                                                                                                                                                                                                                                                                               |
| Effects of tissue outside of arterial blood vessels in pulse oximetry: a model of two-dimensional pulsation.                    | Cross-sectional   | The model of two-dimensional pulsation used in this study considers the change in the relative proportion of light from the oximeter, in addition to the change in the length of the optical radiation path. The calibration curves based on this model may help explaining the variability of this test <i>in vitro</i> and <i>in vivo</i> .                                                                                                                 |
| Arterial line for monitoring SPO <sub>2</sub> in patients with ischemic peripheries.                                            | Cross-sectional   | It is concluded that the arterial line may be used as an extension of the artery to measure SpO <sub>2</sub> , while arterial blood is pulsating in the tube, something which does not ensure accurate reading of blood flow between the arterial tube and the sensor of pulse oximeter.                                                                                                                                                                      |
| Impact of pulse oximetry surveillance on rescue events and intensive care unit transfers: a before-and-after concurrence study. | Case control      | This study implemented a patient monitoring system based on pulse oximetry and notification through wireless pager to the nursing team when alarm limits were exceeded. It was found out that the results of patient monitoring are barely used in the approaches for rescue and transfer from intensive care units, thus constituting a negative factor for the patient.                                                                                     |
| Noninvasive hemodynamic monitoring in the emergency department.                                                                 | Literature review | Non-invasive techniques, along with the advances made in the diagnosis and hemodynamic monitoring of patients, such as pulse oximetry, electrocardiogram, ultrasound, echocardiography, transthoracic bioimpedance, and spectroscopy, indicate a potential revolution in emergency services to explore the control of autonomic nervous system, cardiovascular function and, by extension, the initial phases of compensation in cases of disease and injury. |

Pulse oximeter with plethysmograph was regarded as suitable to use in clinical practice for hemodynamic monitoring of infusion by 5 articles and 2 articles report the use of pulse oximeter with plethysmograph, however, they claim that there is a need for greater scientific relevance, since factors related to the way how pulse oximeter is used and handled can influence on the measurement of values.

There was a consensus among the authors regarding the use in critically ill patients,

either for emergencies and transportation; it is indicated that the use of this technology could reduce the incidence of health problems for the patients.

Since 1930, research on physiology has been conducted using the baseline level of plethysmograph as an index, on a non-quantitative relation to skin vascularization caused by disturbance in the status of temperature and metabolism, drug effects, and regulation mechanisms.<sup>4</sup>

In practice, the baseline of plethysmograph is determined by the interaction of physiological mechanisms. Studies show an increased blood pressure, which fills the vascularization of fingers with blood and establishes an increase in the baseline of plethysmographs.

As the pulsatile signal of plethysmograph is similar in wave morphology, changes in the waveforms of metric variability were significantly associated with hypotension, respiratory volume, capillary pressure, and hypovolemia.

To apply plethysmograph, an analysis of the waveform is performed by means of the most reliable available way. All factors with a potential for error are evaluated: sensor pressure on the skin is constant? Sensor height is constant? Medication time or temperature changes local tissue vascularization? It has been suggested that pulse oximeter with plethysmograph provides an accurate view of the wave.<sup>4</sup>

The technology of this patient surveillance system is efficient, but it is not enough to identify the pathology, there is a need to tackle the problem of labor force. Low values in the ratio between the number of nurses and patients require a balance between sensitivity and specificity. The continuous monitoring of patient will be successful only if it is not a "burden" to an insufficient number of professionals.<sup>5,6</sup>

Noninvasive hemodynamic monitoring proves to be crucial in the emergency department, because it reduces the need for resources.<sup>7</sup> Studies have indicated the growing clinical role played by the use of plethysmograph to anticipate the occurrence of events by analyzing healthy adults.

It proves to be essential to understand the characteristics of the plethysmographic signal time when different thresholds are set. These factors may compromise the final result.<sup>8</sup> Pulse oximeters with plethysmograph require appropriate pulses to distinguish the light absorbed, the parts of arterial blood and venous blood.

The readings may be compromised by situations with loss or decrease in peripheral pulse or body sites inadequate for plethysmographic reading. That is, much rigor is needed to use pulse oximeter in routine procedures. This reinforces the need to define the adequate methods based on scientific relevance.<sup>9</sup>

## CONCLUSION

In general, it may be claimed that most of the studies analyzed are in for the use of pulse oximeter with plethysmograph to assess perfusion.

The panorama provided by the current literature indicates that more attention is devoted to defining the extent to which a particular technique or intervention can contribute to the improvement of subjective well-being of people, something with direct implications on the concepts of quality of interventions provided by health professionals.

This study demonstrated that the decision making of nurses about the use of devices must be based on careful and individualized patient assessment. It is necessary that the professional is scientifically supported to implement effective interventions that meet the patient's needs as quickly as possible.

A fact worth mentioning is the isolated selection of studies from the international literature, conducted with patients treated in health systems different from ours. There is a need for conducting similar studies to evaluate this theme from the Brazilian perspective.

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