

# Low oxygen saturation and discordant arterial blood gas measures have diagnosed a case of hemoglobinopathy

H.W.Abdelwahab , Kh.M. Elsherbiny, M.M.Rezkalla, T.Awad, A.Adel, A.Hweidy

Mansoura University Hospitals: El Gomhouria St. 60, Dakahlia Governorate, 35516, Mansoura City, Egypt

## Abstract

Pulse oximeter is a simple non-invasive equipment used to determine patient's arterial blood oxygen saturation ( $\text{SpO}_2$ ). However, in some people, arterial blood gas measures ( $\text{SaO}_2$ ) are normal and low  $\text{SpO}_2$  values are related to hemoglobin variant rather than cardiac or pulmonary illnesses. **Aim.** We present a case of thalassemia that manifested with low  $\text{SpO}_2$  and discordant  $\text{SaO}_2$ . **Conclusion.** When examining a patient with an unusually low  $\text{SpO}_2$ , the differential diagnosis of a suspected hemoglobin variant should be investigated. Establishing an accurate diagnosis as soon as possible may help avoid unnecessary tests.

**Key words:** low oxygen saturation ( $\text{SpO}_2$ ), hemoglobinopathy, thalassemia, fetal hemoglobin (HbF).

**Conflict of interests.** Authors declare no conflict of interest.

**Funding.** No financial support was provided.

**Ethical expertise.** This study was conducted within the essential ethics guidelines of the Mansoura institutional research board. The patient gave a written informed consent to participate in the study.

© Abdelwahab H.W. et al., 2024

For citation: Abdelwahab H.W., Elsherbiny Kh.M., Rezkalla M.M., Awad T., Adel A., Hweidy A. Low oxygen saturation and discordant arterial blood gas measures have diagnosed a case of hemoglobinopathy. *Pul'monologiya*. 2024; 34 (6): 930–932. DOI: 10.18093/0869-0189-2024-4386

# Низкие показатели насыщения крови кислородом и противоречивые значения газового состава артериальной крови как проявления недиагностированной гемоглобинопатии

Х.В.Абдельвахаб , Х.М.Элшербини, М.М.Резкалла, Т.Авад, А.Адель, А.Хвейди

Больницы Университета Мансуры: 35516, Египет, провинция Дакахлия, Мансура, ул. Эль-Гомхурия, 60

## Резюме

Пульсоксиметр — простой неинвазивный прибор для измерения насыщения артериальной крови пациента кислородом ( $\text{SpO}_2$ ). Однако у некоторых пациентов с нормальными показателями газового состава артериальной крови ( $\text{SaO}_2$ ) низкие значения  $\text{SpO}_2$  обусловлены вариантом гемоглобина, а не сердечными или легочными заболеваниями. **Цель.** Представлено клиническое наблюдение за пациенткой с талассемией, которая проявилась низким показателем  $\text{SpO}_2$  и противоречивыми значениями  $\text{SaO}_2$ . **Заключение.** При обследовании пациентки с необычно низким показателем  $\text{SpO}_2$  проведена дифференциальная диагностика предполагаемого варианта гемоглобина. Быстрая постановка точного диагноза помогла избежать ненужных обследований.

**Ключевые слова:** низкий уровень насыщения артериальной крови кислородом ( $\text{SpO}_2$ ), гемоглобинопатия, талассемия, фетальный гемоглобин (HbF).

**Конфликт интересов.** Конфликт интересов авторами не заявлен.

**Финансирование.** Финансовая поддержка отсутствовала.

**Этическая экспертиза.** Исследование проводилось в соответствии с основными этическими рекомендациями исследовательского совета института Мансуры. Пациентка дала письменное информированное согласие на участие в исследовании.

© Абдельвахаб Х.В. и др., 2024

Для цитирования: Абдельвахаб Х.В., Элшербини Х.М., Резкалла М.М., Авад Т., Адель А., Хвейди А. Низкие показатели насыщения крови кислородом и противоречивые значения газового состава артериальной крови как проявления недиагностированной гемоглобинопатии. *Пульмонология*. 2024; 34 (6): 930–932 (на англ.). DOI: 10.18093/0869-0189-2024-4386

Pulse oximeter is a simple non-invasive equipment used to determine patient's arterial blood oxygen saturation [1]. It is widely utilized in clinical practice and can detect surprisingly low oxygen saturation ( $\text{SpO}_2$ ) in individuals who are subjected to thorough cardiopulmonary examinations to determine the origin of their “hypoxia”. The most prev-

alent cause of low  $\text{SpO}_2$  values is a respiratory illness with poor gas exchange [1]. However, in some of these people, arterial blood gas measures ( $\text{SaO}_2$ ) are normal and low  $\text{SpO}_2$  values are related to a hemoglobin variant rather than cardiac or pulmonary illnesses [2, 3]. In adults, the reported discrepancy between  $\text{SpO}_2$  and  $\text{SaO}_2$  is 3 – 4% [4, 5].

Pulse oximetry calculates the relative amounts of oxy- and deoxyhemoglobin based on their absorption spectra using two wavelengths of light (660 and 940 nm) emitted over a vascular bed. Its accuracy is reduced in the presence of mutant hemoglobins with aberrant absorption spectra [5, 6].

Throughout pregnancy, the major oxygen transporter is fetal hemoglobin (HbF). HbF is gradually replaced by adult hemoglobin (HbA) from the 20<sup>th</sup> week of pregnancy. HbF shows a higher affinity for oxygen, which facilitates oxygen extraction from the blood of the mother to the fetus at lower partial oxygen pressures and leads to the shift of the oxyhemoglobin dissociation curve to the left. Because pulse oximeter calibration curves employ SaO<sub>2</sub> readings from blood samples of healthy people (with nearly little HbF), the accuracy of SpO<sub>2</sub> results in the presence of HbF is uncertain [5].

Cases with low SpO<sub>2</sub> and SaO<sub>2</sub> were classified as concordant and those with low SpO<sub>2</sub> and SaO<sub>2</sub> greater than or equal to 5% higher than SpO<sub>2</sub> as discordant [1].

We present here a case of thalassemia that manifested with low SpO<sub>2</sub> and discordant SaO<sub>2</sub>.

## Case

A 28-year-old female complained of exertional shortness of breath for 2 years. Her dyspnea was progressive and associated with low SpO<sub>2</sub>. Her cousin also suffered from low SpO<sub>2</sub> and shortness of breath, but did not seek medical attention. The patient was referred to our department due to an increase in her dyspnea. Her physical examination was unremarkable, but SpO<sub>2</sub> was 76% when measured with different oximeters and different fingers. SpO<sub>2</sub> level was refractory to oxygen therapy and without evidence of orthodeixia. No evidence of pulmonary embolism or arteriovenous malformation was seen in the post-contrast multi-slice computed tomography scan of the chest. Intrapulmonary and intracardiac shunts were excluded by agitated saline contrast echocardiography and transesophageal echocardiography.

The complete blood count revealed:

- hemoglobin – 10.8 g/dl;
- hematocrit – 39%;
- reticulocyte count – 1.2%.

There was no evidence of hemolysis with total bilirubin (0.7 mg/dl), lactate dehydrogenase (199 mg/dl), and negative direct and indirect Coombs test. The serum ferritin was 224 ng/ml (normal, 13 – 400 ng/ml). Arterial blood gas test when breathing room air showed SaO<sub>2</sub> of 98% and partial pressure of oxygen (PaO<sub>2</sub>) of 100 mmHg. So, hemoglobinopathy was suspected. Hemoglobin electrophoresis showed that the percentage of HbA and HbF was 80.2% (normal, 96.5 – 98%) and 17.7% (normal, 0 – 2%).

Thalassemia was confirmed after further investigations.

## Discussion

Pulse oximetry is a critical diagnostic tool. Nevertheless, if undiagnosed hemoglobin abnormalities are the underlying reason, low SpO<sub>2</sub> may be misinterpreted or lead to unwanted tests. This can result in comprehensive and repeated cardiopulmonary exams [7]. *R. Deyell et al.* [8], illustrate a 10-year-old boy who showed abnormally low SpO<sub>2</sub> following tonsillectomy. Numerous preliminary investigations were completed without a diagnosis. Finally, hemoglobinopathy searches recognized the presence of

a low oxygen affinity hemoglobin variant (hemoglobin Titusville).

More than 1,000 hemoglobin variants have been discovered, and most of them are not associated with abnormal SpO<sub>2</sub> [3]. Nonetheless, in some patients, low SpO<sub>2</sub> is the finding that generates other assessments leading to the identification of an underlying hemoglobin variant [1].

*O. Abdulmalik et al.* discovered hemoglobin Bassett, an abnormal Hb variant with a significantly decreased oxygen affinity, in a male child who had attacks of cyanosis [9]. Carriers of hemoglobin Bassett, Rothschild, and Canebiere have low SpO<sub>2</sub> and low SaO<sub>2</sub>. However, why some hemoglobin variants with low oxygen affinity are associated with discordant oxygen saturation interpretations while others have concordantly low SpO<sub>2</sub> and SaO<sub>2</sub> is unknown [1].

Most of the patients examined in *M. Verhovsek et al.* were asymptomatic, and low SpO<sub>2</sub> was noted incidentally during standard vital signs observation [1]. In many of these cases, *in vitro* co-oximetry on arterial blood showed a normal oxygen saturation, proving the false result of pulse oximetry. Like in our case, investigations for hemoglobinopathy were started only after an extensive cardio-pulmonary assessment failed to discover a cause for hypoxemia.

HbF that was discovered in our case shows an extensively elevated affinity for oxygen. A previous study found a 2.8 – 3.6% underestimation in SpO<sub>2</sub> values in relation to higher HbF levels [10]. Other studies described an overestimation of SpO<sub>2</sub> with higher HbF but did not give a statistical indication to support this statement [5].

## Conclusion

When studying a patient with an unusually low SpO<sub>2</sub>, the differential diagnosis of a suspected hemoglobin variant should be investigated. Establishing an accurate diagnosis as soon as possible may help avoid unnecessary investigations.

## References / Литература

1. Verhovsek M., Henderson M.P., Cox G. et al. Unexpectedly low pulse oximetry measurements associated with variant hemoglobins: a systematic review. *Am. J. Hematol.* 2010; 85 (11): 882–885. DOI: 10.1002/ajh.21810.
2. Hladik A., Lynshue K. Dyshemoglobinemias and pulse oximetry: a therapeutic challenge. *J. Pediatr. Hematol. Oncol.* 2008; 30 (11): 850–852. DOI: 10.1097/MPH.0b013e31817e4a19.
3. Hardison R.C., Chui D.H., Giardine B. et al. HbVar: A relational database of human hemoglobin variants and thalassemia mutations at the globin gene server. *Hum. Mutat.* 2002; 19 (3): 225–233. DOI: 10.1002/humu.10044.
4. Perkins G.D., McAuley D.F., Giles S. et al. Do changes in pulse oximeter oxygen saturation predict equivalent changes in arterial oxygen saturation? *Crit. Care.* 2003; 7 (4): R67. DOI: 10.1186/cc2339.
5. Pritisanac E., Urlesberger B., Schwabegger B., Pichler G. Accuracy of pulse oximetry in the presence of fetal hemoglobin – a systematic review. *Children (Basel)*. 2021; 8 (5): 361. DOI: 10.3390/children8050361.
6. Holbrook S.P., Quinn A. An unusual explanation for low oxygen saturation. *Br. J. Anaesth.* 2008; 101 (3): 350–353. DOI: 10.1093/bja/aen183.
7. Zur B., Bagci S., Ludwig M., Stoffel-Wagner B. Oxygen saturation in pulse oximetry in hemoglobin anomalies. *Klin. Padiatr.* 2012; 224 (4): 259–265. DOI: 10.1055/s-0032-1312612.

8. Deyell R., Jackson S., Spier S. et al. Low oxygen saturation by pulse oximetry may be associated with a low oxygen affinity hemoglobin variant, hemoglobin Titusville. *J. Pediatr. Hematol. Oncol.* 2006; 28 (2): 100–102. DOI: 10.1097/01.mph.0000200685.33291.0a.
9. Abdulmalik O., Safo M.K., Lerner N.B. et al. Characterization of hemoglobin bassett (alpha94Asp-->Ala), a variant with very low oxygen affinity. *Am. J. Hematol.* 2004; 77 (3): 268–276. DOI: 10.1002/ajh.20184.
10. Jennis M.S., Peabody J.L. Pulse oximetry: An alternative method for the assessment of oxygenation in newborn infants. *J. Pediatr.* 1987; 79 (4): 524–528. DOI: 10.1542/peds.79.4.524.

Received: October 06, 2023

Accepted for publication: April 24, 2024

Поступила: 06.10.23

Принята к печати: 24.04.24

#### Authors Information / Информация об авторах

**Abdelwahab Heba Wagih**, MD, Assistant Professor of Chest Medicine, Mansoura University Hospitals; tel.: (0020100) 067-03-65; e-mail: wagihheba84@gmail.com (ORCID: <http://orcid.org/0000-0001-8655-1820>)

**Абделвахаб Хеба Вагих** — д. м. н., доцент кафедры пульмонологии, врач Больницы Университета Мансуры; тел.: (0020100) 067-03-65; e-mail: wagihheba84@gmail.com (ORCID: <http://orcid.org/0000-0001-8655-1820>)

**Elsherbiny Khalid Mohammed**, Assistant Lecturer of Chest Medicine, Mansoura University Hospitals; e-mail: Khalidelsherbiny@mans.edu.eg (ORCID: <https://orcid.org/0000-0003-3898-2540>)

**Эльшербини Халид Мохаммед** — доцент кафедры грудной медицины, Больницы Университета Мансуры; e-mail: Khalidelsherbiny@mans.edu.eg (ORCID: <https://orcid.org/0000-0003-3898-2540>)

**Rezkalla Marina Mahfouz**, Assistant Lecturer of Cardiology, Mansoura University Hospitals; e-mail: riimahfouz@gmail.com (ORCID: <https://orcid.org/0009-0002-8114-6572>)

**Резкалла Марина Махфуз** — доцент кафедры кардиологии, Больницы Университета Мансуры; e-mail: riimahfouz@gmail.com (ORCID: <https://orcid.org/0009-0002-8114-6572>)

**Awad Tamer**, Lecturer of Chest Medicine, Mansoura University Hospitals; e-mail: tawad73@mans.edu.eg (ORCID: <https://orcid.org/0000-0002-2352-1445>)

**Авад Тамер** — преподаватель кафедры грудной медицины, Больницы Университета Мансуры; e-mail: tawad73@mans.edu.eg (ORCID: <https://orcid.org/0000-0002-2352-1445>)

**Adel Asmaa**, Assistant Lecturer of Chest Medicine, Mansoura University Hospitals; e-mail: semoadel91@gmail.com (ORCID: <https://orcid.org/0009-0000-7848-3354>)

**Адель Асмаа** — доцент кафедры грудной медицины, Больницы Университета Мансуры; e-mail: semoadel91@gmail.com (ORCID: <https://orcid.org/0009-0000-7848-3354>)

**Hweidy Asem**, Professor Lecturer of Chest Medicine, Mansoura University Hospitals; e-mail: ahewidy@yahoo.com (ORCID: <http://orcid.org/0000-0001-7072-5478>)

**Хвейди Асем** — профессор кафедры грудной медицины, Больницы Университета Мансуры; e-mail: ahewidy@yahoo.com (ORCID: <http://orcid.org/0000-0001-7072-5478>)

#### Authors Contribution

**Abdelwahab H.W.** — study concept, analysis of data, manuscript preparation and review of the manuscript

**Elsherbiny Kh.M., Rezkalla M.M., Adel A., Mahfouz M.** — data collection

**Awad T., Hweidy A.** — review of the manuscript, analysis of data

All authors have made a significant contribution to the search, analysis, and preparation of the article, read and approved the final version before publication, and accepted responsibility for the integrity of all parts of the article.

#### Участие авторов

**Абделвахаб Х.В.** — концепция исследования, анализ данных, подготовка рукописи и ее рецензирование

**Эльшербини Х.М., Резкалла М.М., Адель А., Махфуз М.** — сбор данных

**Авад Т., Хвейди А.** — обзор рукописи, анализ данных

Все авторы внесли значительный вклад в поиск, анализ и подготовку статьи, прочитали и утвердили окончательную версию перед публикацией, несут ответственность за целостность всех частей статьи.