

## PULSE OXIMETRY: ARE HEALTH PERSONNEL AWARE OF ITS CLINICAL APPLICATIONS AND LIMITATIONS?

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The pulse oximeter measures the differential absorption of red and infrared light by hemoglobin and oxyhemoglobin in pulsatile fractions of blood under the sensor probe. It then calculates the percentage saturation of hemoglobin from a nomogram derived from volunteer studies.<sup>1</sup> Limitations and inaccuracies of pulse oximetry have been extensively reviewed.<sup>2-5</sup> There are many potential sources of error that must be considered for the evaluation and appropriate use of pulse oximeters, i.e., probe placement, signal quality, poor perfusion, dyshemoglobin, dyes, pigments, ambient light, and motion.<sup>3-6</sup> A patient with a saturation reading below 90% might be seriously hypoxic due to the sigmoid shape of the hemoglobin-oxygen dissociation curve.<sup>7</sup>

Most often, nurses, interns and residents are the personnel measuring the patient's oxygen saturation in medical practice and making decisions accordingly. The objective of this study was to verify the degree of knowledge of such personnel in the proper use of the pulse oximeter.

### Materials and Methods

A 16-item multiple-choice questionnaire was administered to a random selection of 106 nurses, interns and residents of three institutions in the Asir region: the Asir Central Hospital, the Abha Maternity Hospital and the Military Hospital. The questionnaire was developed and validated by Luis et al.,<sup>8</sup> and consisted of questions on demography, knowledge, accuracy and clinical aspects of the use of the pulse oximeter. Demographic questions related to the level of training, perceived adequacy of training on pulse oximeter, and its availability in different clinical settings. The knowledge questions related to what a pulse oximeter measures, and the relationship between PaO<sub>2</sub> and various O<sub>2</sub> saturations. The accuracy questions related to the effect of nail polish and motion and poor perfusion on the pulse oximeter readings. The clinical application questions related to normal oxygen saturations

at various ages, determination of PaO<sub>2</sub> at high O<sub>2</sub> saturations and probe replacement and clinical judgement.

To assure the validity and clarity of the questionnaire, the test was administered to a selection of nine anesthetists, intensivists and neonatologists from the three institutes. These physicians had a mean test score of 88.0%, and served as the control. The questionnaire was piloted among 20 residents and interns and nurses. They were asked about the clarity of the questions and whether the difficulty they had with questions resulted from problems of understanding. There were no problems with clarity or the language of the questionnaire. The questionnaire was then administered to an additional 86 candidates among the three institutions in the Asir region.

### Results

The characteristics of the 115 participants (including the control) are summarized in Table 1. The overall total score ranged between 10% to 100%, with a mean of 48.50±25.52% and median test score of 50%. The mean scores were 84.00±21.91% for senior registrars, 47.50±5.0% for third-year residents, 41.67±7.53% for second-year residents, 33.64±10.27% for general nurses, 50.91±22.12% for neonatal nurses, and 27.65±14.80% for interns (Table 2).

Approximately 70% of the participants had experience with using the pulse oximeter, but 72.8% believed they had not received adequate training in the use of this monitoring device. Most of the trainees surveyed use pulse oximeter routinely in the neonatal unit, either in pediatric intensive units or in the emergency department. Fifty-one percent of the participants did not know what the pulse oximeter measures, with the most common erroneous response being that it measures transcutaneous partial pressure of oxygen. Regarding the three questions on the knowledge of the oxyhemoglobin dissociation curve, 22.8% of the participants answered all three questions correctly, 20.2% answered two of the three questions correctly, and 21.1% answered one of the three questions correctly (Table 3). Half of the participants did not know that a decline in oxygen saturation from 95% to 90% accounts for a much greater change in PaO<sub>2</sub> than decrease in oxygen saturation from 80% to 75%, and 48.4% did not know that an oxygen saturation of 90%, under normal metabolic conditions,

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corresponds to a PaO<sub>2</sub> of 60 mm Hg.

There were three questions pertaining to factors affecting the ability of the pulse oximeter to give accurate reading, and 21.1% of the respondents answered all three questions correctly, while 30.7% answered all three questions incorrectly (Table 3). Only 41.7% of the participants knew that at oxygen saturation of <70%, the pulse oximeter is not accurate. Also, 53.6% did not know that nail polish and motion might affect the ability of the pulse oximeter to obtain a reliable reading, and 45.6% did not know that shock may affect the accuracy of a pulse oximeter reading, while hypertension does not.

Of the four questions pertaining to practical aspects of the pulse oximeter, 20.2% of the participants answered all four questions incorrectly (Table 3). Approximately 54% of the participants did not know the normal oxygen saturation of a two-year-old, and 50% did not know the normal oxygen saturation of a newborn.

### Discussion

Our study showed variability in the participants' knowledge of pulse oximetry. Interns and ward nurses had the lowest scores, followed by first-, second- and third-year residents, and neonate and intensive care nurses. Fourth-year residents and senior registrars had the highest scores among these groups, however, the total overall score was low. This reflects a marked deficiency in knowledge of the use of the pulse oximeter, especially in house officers and ward nurses. These health personnel are the ones responsible for monitoring the patients and are the ones most likely to make decisions that will subsequently affect the management of the patients. For instance, early detection of hypoxic episodes should lead to earlier corrective measures and prevent adverse consequences of hypoxemia, such as arrhythmias, myocardial ischemia, and brain ischemia.<sup>9</sup>

Neonatal and intensive care nurses scored higher than ward nurses and interns, perhaps because of the fact that these personnel use the pulse oximeter on a more regular basis and are also in more regular contact with expert physicians, such as intensivists and neonatologists, compared to the nurses in the ward. Though interns rotate through the pediatric ward and the neonatal unit, they scored lowest among the medical personnel surveyed in this study.

This study shows that education being given to hospital personnel on the uses and limitations of pulse oximetry is inadequate. Interestingly, Abha Maternity Hospital scored highest among the three institutions. This may be due to the fact that those who participated in the questionnaire were neonatal nurses and senior registrars. The other two institutions had almost the same scores. These findings confirm the generally low level of knowledge about pulse oximetry.

TABLE 1. *Distribution of the studied participants according to level of training.*

Level	N	%
Neonatal and intensive care nurses	23	20
Ward nurse	21	18.2
Intern	30	26.08
1 <sup>st</sup> year resident	7	6.08
2 <sup>nd</sup> year resident	2	1.73
3 <sup>rd</sup> year resident	7	6.08
4 <sup>th</sup> year resident	8	6.95
Senior registrar	8	6.95
Control	9	7.82
Total	115	100.00

TABLE 2. *Mean and SD of the total score (%) according to level of training.*

Level of training	N	Mean±SD
Neonatal and intensive care nurses	23	50.91±22.12
Nurse	21	33.64±10.27
Intern	30	27.65±14.80
1 <sup>st</sup> year resident	7	41.67±7.53
2 <sup>nd</sup> year resident	2	41.67±7.53
3 <sup>rd</sup> year resident	7	47.50±5.00
4 <sup>th</sup> year resident	8	61.67±27.14
Senior registrar	8	84.00±21.91
Control	9	88.00±7.87
Total	115	48.50±25.52

TABLE 3. *The percentage of participants correctly answering questions concerning knowledge of ODC, AO and PO.*

Correct answers	ODC* (%)	AO (%)*	PO (%)*
None	36.0	30.7	20.2
1	21.1	29.8	31.6
2	22.8	18.4	21.1
3	22.8	21.1	9.6
4	—	—	17.5

\*ODC=oxyhemoglobin dissociation curve; AO=accuracy of the oximeter; PO=pulse oximeter.

Most of the previous studies on pulse oximeters were done mainly to study the efficacy and accuracy of the different types. This study was aimed at addressing issues concerning the knowledge and clinical application of pulse oximetry among health professionals. We conclude that the understanding of pulse oximetry by pediatric house staff is variable and often inadequate, and may lead to inappropriate management decisions. Some house staff are not aware of the basic principles of pulse oximetry, and may make serious errors in interpretation of its readings, thus contributing to patient morbidity.

Knowledge of the basic principles, clinical and technical considerations, as well as understanding of the oxyhemoglobin dissociation curve are important in monitoring patients properly and rendering adequate care. These can be achieved by giving training on pulse oximetry to medical staff at the level of nurses, interns, and residents. This might be done through additional lectures at undergraduate courses, especially those related to bedside teaching, and also by training postgraduate students on plastic models and awarding them credit hours in their continuous medical education (CME) activities.

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