

ORIGINAL

PROF-1112

# PULSE OXIMETRY; KNOWLEDGE AMONG MEDICAL STUDENTS AND NURSING STAFF



**DR. ABDUL-HAMEED CHOHDRI,  
MBBS, DIBA (Iran)**

Assistant Professor, Department of Anesthesiology,  
Nemazee Hospital, Shiraz University of Medical  
Sciences, Shiraz, Iran

**DR. MOHSEN DAUGHANI, M.D IRAN (G.P)**

Medical student, Department of Anesthesiology,  
Nemazee Hospital, Shiraz University of Medical  
Sciences, Shiraz, Iran

**ABSTRACT...** [hameedchoheri@yahoo.com](mailto:hameedchoheri@yahoo.com) **Background/Aim:** Pulse oximetry has emerged as a clinical tool in anesthesia and is becoming popular in developing countries. Unfortunately, its use is usually not accompanied by appropriate staff training. The aim of this study was to evaluate the knowledge about pulse oximetry among the 7<sup>th</sup> year medical student Interns (MS) and nursing staff (NS) of Intensive Care Unit (ICU), Coronary Care Unit (CCU) and Recovery Room (RR) of four medical-school affiliated hospitals in Shiraz, Iran. **Study Period:** Feb 2001- Feb 2002 **Materials and Methods:** A 14-item questionnaire (4 demographic and 10 knowledge), multiple-choice and open ended, was developed to assess knowledge of pulse oximetry. Among 150 7<sup>th</sup> year medical students and 200 nursing staff, 40 from each group was randomly selected and invited to complete the questionnaire. **Results:** A 100% response rate was achieved. All of the participants used pulse oximetry regularly in their daily work. The mean test scores for MS and NS were  $60.5 \pm 21$  and  $49 \pm 17\%$ , respectively ( $p < 0.05$ ). None of the participants had adequate training in the use of pulse oximetry. **Conclusion:** Our study revealed that medical students and staff nurses were untrained in pulse oximetry, lacked knowledge of basic principles, and made serious errors in interpretation of readings. Therefore, we recommend that medical schools and nurse training programs place emphasis on teaching the principles and applications of pulse oximetry and the oxyhemoglobin dissociation curve.

**Key words:** Pulse oximeter, O<sub>2</sub> saturation, knowledge, medical students, nurse staff, training course.

## INTRODUCTION

The pulse oximeter has become an essential tool in the modern practice of medicine. Pulse oximetry has emerged as a clinical tool in anesthesia, emergency medicine, pregnant women, newborn monitoring and neonatal intensive care units, within the last 10 years as a result of recent technological and theoretical advances<sup>1-3</sup>. Oximeters measure the different absorption spectra of oxygenated and deoxygenated hemoglobin<sup>3</sup>.

Electronic measures of oxygenation at the peak of the pulse allow computation and display of oxygen saturation of the arterial blood almost instantly. Correlation coefficients between pulse oximetry and direct blood oxygen saturation measurement range from 0.77-0.99 when oxygen saturation is greater than 60%<sup>2,3</sup>. The method is noninvasive (a clip or tape on a finger), simple to operate, and adaptable to various patient populations. Pulse oximetry monitors continuously and

instantaneously, is responsive to change, and is accurate. Factors adversely affecting the accuracy of pulse oximeter output include transducer movement, peripheral vasoconstriction, a nonpulsating vascular bed, hypotension, anemia, changes in systemic vascular resistance, hypothermia, presence of intravascular dyes, and nail polish<sup>3</sup>.

The use of the pulse oximeter is becoming popular in developing countries. Unfortunately, its use is usually not accompanied by appropriate staff training. The aim of this study was to evaluate the knowledge about pulse oximetry among the medical students (MS) and nursing staff (NS) of Intensive Care Unit (ICU), Coronary Care Unit (CCU) and Recovery Room (RR) of four medical-school affiliated hospitals in Shiraz, Iran.

## MATERIALS AND METHODS

A questionnaire survey of last year MS and NS at four medical school affiliated hospitals in Shiraz, Iran was conducted. The 14-item multiple choice questionnaire that had been compiled and validated by previous studies<sup>4-7</sup>, was administered to 7<sup>th</sup> year medical students and nursing staff of Intensive Care Unit (ICU), Coronary Care Unit (CCU) and Recovery Room (RR). Among 150 7<sup>th</sup> year medical student and 200 nursing staff of these wards, who regularly and daily used pulse oximeter, 40 from each group was randomly selected and invited to complete the questionnaire. Of the 14 questions, 4 related to demographic characteristics, experience with oximeters and the rest evaluated the perceived adequacy of knowledge on pulse oximetry, practical applications of pulse oximeters, its accuracy and limitations, its use in various clinical settings (Appendix I).

To assure the clarity and validity of the questions, questionnaire of four previous studies performed by Kruger, Faponle, Rodriguez and Stoneham et al<sup>4-7</sup> were studied and a selection of the questions was administered to 6 experienced pulmonologists and internist and asked about the clarity of the questions and whether the difficulty they experienced resulted from problems with comprehending the questions. There were several problems with clarity and amount of evaluating knowledge of pulse oximetry and hence, some alterations

were made. The test was completed anonymously and voluntarily.

All data were analyzed and computed by SPSS (Chicago, IL) software, version 10.0, and Microsoft EXCEL (Microsoft, Redmond, WA) software. Data are expressed as mean  $\pm$  standard deviation (SD) and 95% confidence interval (CI) are also given when essential. The results were analyzed using the in-dependent-samples *t*-test (two-tailed). *p* values less than 0.05 were considered statistically significant.

## RESULTS

A 100% response rate was achieved. All of the participants used pulse oximetry regularly in their daily work. The mean test scores for MS and NS were  $60.5 \pm 21$  and  $49 \pm 17$  % (out of 100), respectively ( $p < 0.05$ ). The MS had significant higher knowledge on pulse oximetry compared to the nurse staff ( $p < 0.05$ ). None of the participants had adequate training in the use of pulse oximetry. All of the MS were from the surgery ward. Seventeen (42.5%) NS were from CCU, 13 (32.5%) from ICU and 10 (25%) were from RR.

Test results for questions relating to the accuracy and limitations of the pulse oximeter, knowledge about function of pulse oximetry and practical and clinical applications of pulse oximetry are summarized in Table-I. The rest of the results are shown in Appendix I. The weakest scores were obtained in practical applications of pulse oximetry (Table-I).

## DISCUSSION

The importance of pulse oximetry monitoring has long been recognized for patients in the operating room, recovery room, the intensive care unit, as well as patients undergoing respiratory procedures (bronchoscopy), gastrointestinal (endoscopy) interventions, cardiac catheterization, sleep studies and exercise testing<sup>8</sup>. In intensive care units, pulse oximetry is usually used to monitor patients with chronic obstructive pulmonary disease that are usually intubated, under mechanical ventilation, and those with severe cardiorespiratory disease.

**Table-I. Results of correct answers of MS and NS to different parameters in the questionnaire evaluating the limitations and errors, knowledge of function, practical and clinical applications and total knowledge score on pulse oximeter.**

Parameter Evaluated	MS	NS	ALL
Limitation and error	62.5%	77.5%	70%
Knowledge of function of pulse oximetry	73.3%	65.8%	69.6%
Practical and clinical applications	53.8%	36.3%	45.1%
Total knowledge score	60.5%	49%	54.7%

*MS: Medical Students; NS: Nurse Staff; ALL: All groups*

**Table-II. Comparison of knowledge of pulse oximetry among medical staff in different centers**

Study	Received Training Course	Correct Scoring %
Our study (Iran, 2005)	0%	54.7%
Rodriguez LR et al (USA, 1994)	67%	64.3%
Stoneham MD et al (UK, 1994)	2%	~3%
Kruger PS et al (Australia, 1997)	<50%	68.5%
Attin M et al (USA, 2002)	-	66%
Fapnole AF et al (Nigeria, 2002)	28%	<10%
Davies G et al (New Zealand, 2003)	16%	>70%
Toeh L et al (Australia, 2003)	26-36%	~65-70%
Popovich DM et al (USA, 2004)	84%	~50-60%

This is the first study in Iran that has assessed the knowledge of pulse oximetry among medical staff. A comparison between the results obtained from our study with those observed in other similar studies is summarized in Table-II. Unfortunately, the results obtained are lower than those observed in other studies<sup>4-12</sup>. This is because none of the participants in our study (medical students and nurse staff) had received training. The lowest rate of training in other studies belonged to a study done by Stoneham *et al*, in UK<sup>7</sup>. Their study was very similar to our study, in which they investigated the knowledge of junior doctors and nursing staff about pulse oximetry as used on seriously ill patients in a District General Hospital in Exeter, UK. 30 medical or surgical preregistration house officers or senior house officers

and 30 staff nurses had answered a structured questionnaire. Questions used in Stoneham *et al* study were about the theory behind pulse oximetry, factors affecting readings, "normal" values in various patients, values in hypothetical clinical situations, and what training subjects had received<sup>7</sup>. Responses were scored against standard answers from reference texts. Stoneham *et al* observed that 97% of doctors and nurses did not understand how a pulse oximeter worked and were confused about factors influencing readings. Respondents had given a wide range of acceptable saturation values (e.g., 90-100% for a fit adult), thus demonstrating poor understanding of physiological principles. Serious errors were made in evaluating saturation readings in hypothetical clinical situations.

Only 1 doctor had received formal training in the use of pulse oximetry. They had concluded that junior doctors and staff nurses were untrained in pulse oximetry, lacked knowledge of basic principles, and made serious errors in interpretation of readings. Therefore, training was needed for staff that use pulse oximeters<sup>7</sup>.

In another similar study performed in Australia by Kruger and Longden, 203 medical and nursing staff were evaluated on their knowledge of pulse oximetry. The study was performed at a regional base hospital and their results higher than ours<sup>4</sup>. Although the scoring for knowledge of pulse oximetry was higher than those obtained in our study, (68.5% compared to 54.7% in our study) however the low rate brought Kruger and Longden to the conclusion that appropriate staff education must ensure a basic understanding of the operating principles of the instrument<sup>4</sup>. Rodriguez *et al* had similar results to Kruger and Longden<sup>6</sup>. Their study looked at junior medical officers (JMO) only (up to four postgraduate years) and showed their mean test score to be 64.3%, with a range of 10–100%<sup>6</sup>. The median test score in the study by Rodriguez *et al*. was 70% (compared to 54.7% in the present study). Forty-three percent (compared to 100% in the present study) of JMO believed that training in the use of pulse oximetry was inadequate<sup>6</sup>. In another similar study done by Faponle and Erhabor in Nigeria, a developing country, similar results to our study was obtained<sup>5</sup>. They assess the knowledge of 25 health care professionals at the Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife, Nigeria, about the pulse oximeter using a questionnaire. A 100% response rate was achieved from staff participating in the study. Most (92%) of the participants (medical (M) 44%, nursing (N) 52% and medical student (MS) 4% had seen the equipment before, being used in the hospital. Only 28% claimed to have been trained in its use though. The answers to the clinical questions generally reflected a poor understanding of the principles of pulse oximetry. Faponle and Erhabor also concluded that in order to improve patient's care by introducing such equipment can only be achieved by accompanying its introduction with staff training on the use of this equipment<sup>5</sup>.

Attin *et al* developed an educational program and

demonstrated a dramatic improvement in the knowledge of the participants<sup>11</sup>. A test/survey of 17 true-false questions based on the research-based practice protocol of the American Association of Critical-Care Nurses was developed to evaluate current knowledge of pulse oximetry. A convenience sample of medical, nursing, and respiratory therapy staff were invited to complete the test/survey before and several months after an educational program to improve staff members' knowledge of pulse oximetry. The program included educational forums, policy changes, competency checklists, and verification of inclusion of research-based principles in orientation programs. A total of 442 staff members completed the test/survey given before the educational program: 331 nurses, 82 physicians, and 29 respiratory therapists. The overall mean percentage of correct answers was 66% (compared to 54.7% in our study). Differences between disciplines were significant: respiratory therapists scored slightly higher (76%) than did nurses (64%) and physicians (66%) ( $P = 0.01$ ). The scores on the test/survey given after the educational program increased significantly, from 66% to 82% ( $P < 0.01$ ). Attin *et al* concluded that their educational project improved staff members' knowledge of pulse oximetry monitoring<sup>11</sup>.

In the questions pertaining to the accuracy and limitations of the pulse oximeter, our results were slightly higher than previous studies<sup>4-12</sup>. Other previous studies have also demonstrated this lack of knowledge among medical staff concerning the principles, practical applications and associated limitations of pulse oximetry<sup>8</sup>.

Another interesting result obtained in our study was the 100% response rate observed among our participants. This may be due to the higher tendency to learn and that the medical staffs are eager to increase their knowledge. In our studies, however, the lower rate of response was thought to be caused because of the fact that the non-respondents chose not to do the test due to deficiency of knowledge in pulse oximetry<sup>8</sup>.

The weakest point of knowledge was observed with practical and clinical applications. This is also the most important aspect of using pulse oximetry. Other studies

also demonstrated similar results<sup>10,12</sup>. In a study done by Popovich *et al*, the knowledge base related to pulse oximetry technology and clinical interpretation of the data given were assessed in a total of 68 participants--nurses, respiratory therapists, and resident physicians at a large general pediatric unit of a children's hospital. The survey consisted of open-ended questions. Preliminary analysis revealed that 84% of the clinicians felt they received adequate training<sup>10</sup>. This is the higher rate of trained participant observed in the previous reported studies. 84% correctly identified what a pulse oximeter measured; 40% correctly identified how a pulse oximeter worked, but only 15% had a correct understanding of the oxyhemoglobin dissociation curve. Clinicians identified a wide range of normal arterial oxygen saturation values and made numerous errors in evaluating saturation readings in hypothetical clinical situations. This is also similar to the 4 present study. Popovich *et al* concluded that although the majority of pediatric staff felt well trained and knowledgeable about pulse oximetry, there was a lack of knowledge of basic principles<sup>10</sup>. The results of Popovich *et al* study had implications for basic professional education programs and the orientation and ongoing education of pediatric health care providers.

From this limited survey, we confirm that there is no formal training in the use of pulse oximetry in our hospitals. In conclusion, there is an insufficiency of knowledge and understanding among medical staff concerning the principles, clinical applications and limitations of pulse oximetry.

If the health-care professional understands the device's operation and the principles behind the oxyhaemoglobin dissociation curve, the pulse oximeter is certainly a useful tool in providing quality patient care. More emphasis should be placed on teaching both medical students and nurse staff the principles of pulse oximetry with regular updates to optimize clinical care of patients and to minimize inappropriate decisions in the treatment of patients.

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## APPENDIX-1

### Pulse oximetry questionnaire

- |    |  |                 |
|----|--|-----------------|
| 1. | Please fill out the following information:                   | 40 MS           |
| a. | Job:   | 40 NS           |
|    | I. medical student   |                 |
|    | II. nurse staff  |                 |
| b. | Ward: (i) Surgery; (ii) Internal medicine                    |                 |
| 2. | Do you regularly work with pulse oximeter?                   | NS: 100% yes    |
| a. | Yes  | MS: 100% yes    |
| b. | No   |                 |
| 3. | Have you received any teaching in the use of pulse oximeter? | NS: 100% no     |
| a. | Yes  | MS: 100% no     |
| b. | No   |                 |
| 4. | Were have you learned about how to use pulse oximeter?       | NS: 100% = b    |
| a. | Read from the book   | MS: 39(97.5%)=b |
| b. | From other medical students or nurse staff                   | and 1(2.5%) = a |
| c. | Learned in a training course                                 |                 |

## KNOWLEDGE OF PULSE OXIMETRY

- |    |  |                 |
|----|--|-----------------|
| 5. | Which of the following effects the accuracy of pulse oximetry (5 correct out of 8 is needed for full score)? | Correct Answer: |
| a. | Nail polish  | NS: 31 (77.5%)  |
|    | a. Yes   | MS: 25 (62.5%)  |
|    | b. No  |                 |
| b. | Black skin   |                 |
|    | a. Yes   |                 |
|    | b. No  |                 |
| c. | Anemia   |                 |
|    | a. Yes   |                 |
|    | b. No  |                 |
| d. | Jaundice   |                 |
|    | a. Yes   |                 |
|    | b. No  |                 |
| e. | Peripheral vasoconstriction  |                 |
|    | a. Yes   |                 |
|    | b. No  |                 |
| f. | Cardiac Arrhythmia   |                 |
|    | a. Yes   |                 |
|    | b. No  |                 |

g. Shiver

- a. Yes
- b. No

h. CO poisoning

- a. Yes
- b. No

6. What two parameters does pulse oximetry measure? Correct Answer:  
NS: 40 (100%)  
MS: 39 (97.5%)  
MS: 39 (97.5%)
- a. PaO<sub>2</sub> (partial pressure of oxygen) and heart rate
  - b. Heart rate per minute and percentage of hemoglobin which is oxygenated (oxyhemoglobin) (✓)
  - c. TCO<sub>2</sub> (transcutaneous partial pressure of oxygen) and PaO<sub>2</sub>
7. How does pulse oximetry work? Please explain thoroughly. Correct Answer:  
NS: 1 (2.5%)  
MS: 10 (25%)
8. What is the normal saturation for an adult, in room air? Correct Answer:  
NS: 38 (95%)  
MS: 39 (97.5%)
- a. 85-90%
  - b. 90-92%
  - c. 93-95%
  - d. 95-100% (✓)
9. If in an adult patient the oxygen saturation drops to an abnormal level, what is the most urgent response? Correct Answer:  
NS: 2 (5%)  
MS: 0 (0%)
- a. Check airway-breathing and circulation if normal check the pulse oximeter (✓)
  - b. Give nasal O<sub>2</sub> and call the senior doctor
  - c. Give O<sub>2</sub> and perform arterial blood gas (ABG)
10. An elderly patient, has been admitted in ICU for his pneumonia, and has 75% O<sub>2</sub> saturation on pulse oximeter. After applying 6 liters of nasal O<sub>2</sub>, his saturation increased to 85%. What is the next step? Correct Answer:  
NS: 2 (5%)  
MS: 11 (27.5%)
- a. Give more O<sub>2</sub>
  - b. Perform ABG (✓)
  - c. Increase O<sub>2</sub> and then ABG if not responded
  - d. No more treatment is needed
11. A known case of Chronic Obstructive Pulmonary Disease (COPD) is receiving 24% Oxygen with mask. His O<sub>2</sub> saturation on pulse oximeter is 90%. What is the next best management? Correct Answer:  
NS: 13 (32.5%)  
MS: 23 (82.5%)
- a. Increase the O<sub>2</sub>
  - b. The patient is a COPD and has weak respiratory muscles, therefore we should decrease the O<sub>2</sub>
  - c. Perform ABG
  - d. Lower than normal O<sub>2</sub> saturation is normal for patients with COPD, therefore no further management is required. (✓)

12. A 45-year-old man with tension pneumothorax and central cyanosis has been admitted in the ICU. O<sub>2</sub> saturation on pulse oximeter is 100%. What is the next step in management? Correct Answer:  
a. Since O<sub>2</sub> saturation is 100%, there is no need for additional O<sub>2</sub> NS: 24 (40%)  
b. The machine is not working correctly; chest tube should be inserted according to the patient's clinical evaluation (✓) MS: 31 (77.5%)  
c. Intubate the patient and Start O<sub>2</sub>  
d. Start O<sub>2</sub>
13. What does the pulse oximeter show, immediately after cardiac arrest? Correct Answer:  
a. It will show a flat wave with alarm working NS: 20 (50%)  
b. The saturation will decrease to below normal MS: 18 (45%)  
c. Since the pulse oximeter needs pulse to function correctly, it will show nothing and the alarm will work (✓)  
d. It will show decrease in pulse rate
14. What does the pulse oximeter show, immediately after a respiratory arrest? Correct Answer:  
a. The saturation will drop to below normal, until secondary to hypoxia, the patient develops cardiac arrest (✓) NS: 34 (85%)  
b. It will show a flat wave with alarm working MS: 36 (90%)  
c. It will show decrease in pulse rate

*MS: Medical Students; NS: Nurse staff*