

*The*  
**FORUM** *Offers*  
*Recommendations on Best Practices in*  
**PEDIATRIC PULSE OXIMETRY**

by the Pulse Oximetry FORUM, Child Health Corporation of America

**P**ulse oximetry is a quick, noninvasive means of assessing and monitoring arterial oxygen saturation. When used properly, the monitors can reduce costs for health systems by identifying patients at risk, directing treatment priorities, and prompting appropriate intervention. The use of pulse oximetry in situations where it is not technically reliable, in areas where it cannot be effectively

monitored, or by personnel who are not trained in its interpretation may actually increase institutional liability. Furthermore, the overutilization of pulse oximetry has resulted in excessive operational costs for some FORUM institutions.

#### **A no-stick, no-pain measurement for kids**

Assessing a patient's oxygenation status using pulse oximetry provides a noninvasive method to estimate the saturation of hemoglobin with oxygen (SaO<sub>2</sub>). This estimate of SaO<sub>2</sub> by pulse oximetry is referred to as SpO<sub>2</sub>. In the past, arterial blood gases (ABGs) had been used to diagnose hypoxemia. ABGs require a deep, often painful puncture of an artery to collect blood for analysis. In children, the discomfort and stress imposed by the arterial puncture can alter their breathing pattern (and, therefore, ABG values) and cause agitation and clinical deterioration. The ABG values resulting from such an encounter often give little useful information about the patient's oxygenation status.

Unlike the procedure for obtaining ABGs, pulse oximetry is painless, relatively easy to apply,

### **Take-Home Notes**

- According to FORUM members' experiences, pulse oximetry is widely misused. It is overused — taxing the hospitals resources largely out of fear of increased liability. Yet, such overuse may result in increased liability.
- Pulse oximetry is sometimes underused, resulting in inadequate monitoring of patients at risk for respiratory distress. Underuse also results in increased liability for institutions and clinicians.
- The incorporation of institution-wide management policies and committee oversight may improve the efficiency of pulse oximetry utilization.
- Adequate training of caregivers may result in more appropriate clinical application, improve technical and logistic management of pulse oximetry resources, and enhance the quality of the data given by pulse oximeters.

and causes minimal agitation. As such, it has become the standard for assessing hypoxemia in pediatric patients with respiratory distress. Mower and colleagues<sup>1</sup> referred to pulse oximetry as “the fifth pediatric vital sign.” The value of pulse oximetry monitoring has become so apparent that its use has expanded to include continuous monitoring of oxygenation during surgery, postanesthesia care, and intensive care.

Continuous monitoring of SpO<sub>2</sub> during surgery has become the standard of care for both adult and pediatric patients, providing indirect, continuous information about airway security, ventilation, and oxygenation during surgery and during recovery from anesthesia. Continuous pulse oximetry is also the standard of care for most patients admitted to intensive care units (ICUs) because patients admitted to these units are at risk for respiratory compromise. Continuous pulse oximetry monitoring can detect subtle variations in SpO<sub>2</sub> before cardiovascular changes occur. These changes in SpO<sub>2</sub> over time may help determine the likely cause of hypoxemia, the best course of action, and the urgency required.

Today, continuous pulse oximetry is widely used in some facilities for patients who require only general floor care, prompted largely by hospitals' perception of liability and influenced by health care reengineering. The FORUM believes that this expanded utilization has resulted in substantial costs to hospitals for monitors, sensors, and human resources.

## About the FORUM..

The Child Health Corporation of America (CHCA) is a cooperative of 38 children's hospitals in the United States that facilitates group purchasing, cost reduction, strategic planning, and managed care. CHCA's Management Engineering Services Division was created in 1995 and works to reduce operating costs of its members through a focus on product utilization, logistics management, and best practices in supply management.

The CHCA cooperative's Pulse Oximetry Forum (FORUM) was established in May 1996 when a focus group of 10 directors of pediatric respiratory care convened to determine best practices for pulse oximetry utilization in the care of sick children. The FORUM is facilitated by Management Engineering Services Division of CHCA and is funded by participating member hospitals. Under the leadership of Sue Ciarlariello, BA, RRT, members of the FORUM worked together to write this article.

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### Existing standards and guidelines

In addition to the AARC's comprehensive guideline on pulse oximetry,<sup>2</sup> other professional organizations have published guidelines that recommend using pulse oximetry to monitor oxygenation on patients in critical care settings (Society for Critical Care Medicine),<sup>3,4</sup> during sleep studies and endoscopy involving children (American Thoracic Society),<sup>5,6</sup> after sedation for diagnostic or

therapeutic procedures (American Academy of Pediatrics),<sup>7</sup> for pain management (Agency for Healthcare Research and Quality),<sup>8</sup> and during surgery and postanesthesia care (American Society of Anesthesiologists).<sup>9,10</sup> However, guidelines for the application of pulse oximetry for patients admitted to general care units are either lacking or are stated in general terms because of the paucity of reliable data.<sup>11</sup>

Controversy exists as to the value of pulse oximetry for

screening and/or monitoring. Anderson, et al,<sup>12</sup> found that in only three of 437 cases was pulse oximetry instrumental in diagnosing a serious illness, and only 69 had their care plans changed because of pulse oximetry data. Yet, one author writes, “The superiority of pulse oximetry over clinical judgment to detect hypoxemia is well documented.” This writer further suggests that pulse oximetry be used as a surveillance method for those children at risk for hypoxia and recommends continuous monitoring for patients with unstable respiratory status, history of apnea, or at risk for an obstructed airway.<sup>13</sup>

In a pediatric study, Kozlowski<sup>14</sup> suggests the patients best served by continuous monitoring were those with primary pulmonary disease during the first four days of admission to expedite the oxygen weaning

process and those receiving significant pharmaceutical pain management.

**A look at costs**

Through an examination of the existing literature and the experience of both hospitals and industry, the FORUM believes that the expanded utilization of pulse oximetry into general care units has delivered limited benefit to patients and represents additional operational costs for hospitals. As such, we have sought to develop a rational plan for guiding the appropriate utilization of pulse oximetry in hospitalized pediatric patients.

Participating hospitals of the FORUM submitted actual sensor utilization and cost information. A wide cost discrepancy (\$32,920 to \$585,000)\* exists among the 10 reporting hospitals, indicating substantial variation in the type and quantity of sensors used and a difference in clinical practice pat-

terns (see Table 1). However, hospital unit-specific cost data are difficult to compare because accounting and distribution practices vary among institutions.

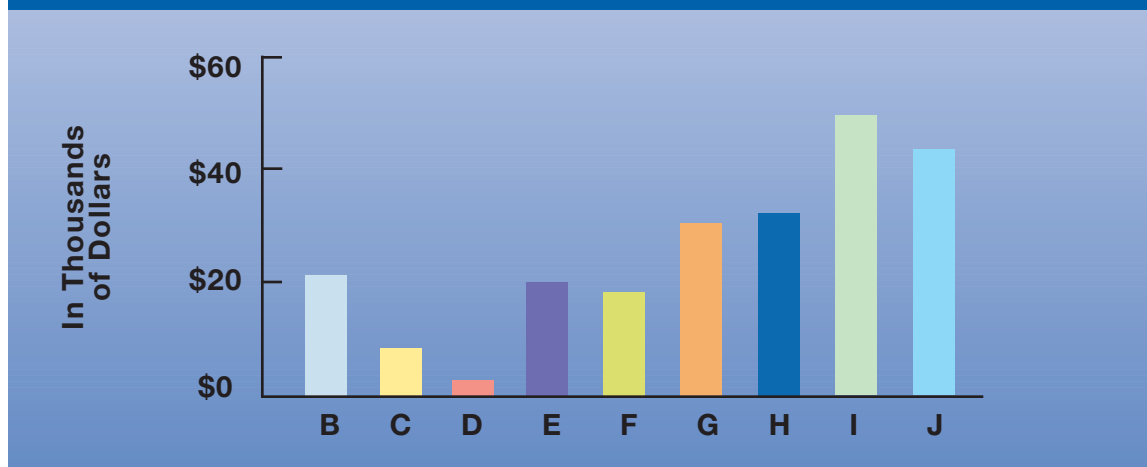
Nine of the 10 hospitals used disposable sensors, primarily. One FORUM hospital used reusable sensors, which kept its overall supply cost under \$100,000 per year. A comparably sized institution, using primarily disposable sensors, spends more than \$100,000 per year for pulse-oximetry sensors.

Although permanent sensors have a high initial unit price (approximately \$200 to \$300) and disposable sensors have a lower initial cost (\$15 to \$20), the high volume of single-use disposable sensors used results in a much higher operating cost. Most manufacturers of reusable sensors provide an extended warranty (for example, six months) on sensor operation, which saves replacement costs

**Table 1. Costs of Providing Pulse Oximetry in 10 FORUM Institutions**

Beds	Hospital	Monitors			Sensors	
		Cases	Costs	Recycle Savings		
100	A	65	423	NA	NA	
155	B	99	743	\$178,715	\$23,413	
188	C	73	624	165,546	7,572	
195	D	110	349	97,244	2,448	
199	E	144	633	168,191	21,310	
214	F	101	1,094	320,019	19,400	
220	G	127	1,043	238,113	35,824	
222	H	225	775	221,859	38,541	
304	I	292	1,800	585,000	52,239	
322	J	214	1,335	363,669	43,533	

**Figure 1. Annual cost savings incurred by FORUM institutions who participated in a pulse oximeter sensor recycling program. Each bar represents data from a different FORUM hospital.**



temporarily. The one FORUM hospital that used permanent sensors also realized substantial savings through a permanent sensor capitated service and replacement contract; total reusable expense was \$39,500 in 1996.

Representatives of FORUM hospitals observed that the highest usage of disposable sensors is in the operating room and emergency department where a high volume of short-term patients is seen. Some FORUM hospitals participate in a disposable sensor recycling program and report cost savings of 5 to 17 percent per year (see Figure 1).

The cost of labor to apply, monitor, and respond to pulse oximetry and its alarms was not quantified but discussed at length by the FORUM. The application of pulse oximetry without clear indications was noted as a universal concern. The extension of continuous monitoring into the general

care units may not substantially affect supply costs. However, it does impose additional tasks and distractions for clinical staff assigned to those units.

#### Liability issues

With the widespread use of pulse oximetry throughout health care organizations, the liability of institutions and caregivers has become an important consideration. Continuous pulse oximetry monitoring in general care units is perceived to be nuisance-prone in the more active patients and logistically difficult on units without central monitoring. Two studies support these perceptions.

A 1992 quality assurance study conducted at a FORUM hospital in Columbus, OH, was presented to the FORUM. The study demonstrated a total of 875 oximeter alarms in 23 infants during multichannel somnograms. Only 28 alarms had pulse correlation that represented true hypoxemia; 847 were false

alarms, and only 14 (50 percent) of the true alarms were noted as events on the nursing notes. Motion artifact was cited as the most common cause for false alarms in these infants. Alarm silencing was required 30 to 40 times per patient during the 8.85 hour (average) study period.

A FORUM hospital in New Orleans, LA, conducted a quality assurance study to address the problems of proximity when providing continuous monitoring on their general care units. They found:

- 75 percent of the continuous pulse oximeters were not within audible range of the nurses' station;
- 25 percent were in audible range but required the door be open at all times; and
- 75 percent of the patients had pulmonary disease and/or an infectious disease process that required the door be closed for isolation.

Members of the FORUM noted that in a general care unit, the use of pulse oximetry in

rooms beyond audible range of caregivers is common. Nuisance alarms during continuous pulse oximetry can be an annoyance to the patient, family, and staff, which can lead to general desensitization to the alarms, increased personal anxiety, and excessive attention to the monitor rather than the patient. The New Orleans study also noted that alarms were being disabled by family members to reduce the annoyance.

The liability associated with pulse oximetry can be staggering as witnessed by the following cases involving a clinician's inappropriate response to a nonfunctioning pulse oximeter (Case 1), a clinician's failure to respond appropriately to the pulse oximeter data (Case 2), and the absence of pulse oximetry monitoring in the presence of clear indications (Case 3).<sup>†</sup>

*Case 1* — In 1993, a 13-year-old boy, who had been involved in an automobile accident a week and a half earlier, died when his tracheostomy tube became occluded. Among the factors that were implicated in his death was that the pulse oximeter had fallen off the child and a nurse did nothing to otherwise evaluate the boy. The allegation was that if the pulse oximeter continued to fall off the patient, the hospital had a duty to constantly monitor such a patient. The family was awarded \$252,475.

*Case 2* — In 1996, a three-year-old girl died following an asthma attack. The physician ordered that the child be placed in an oxygen tent to maintain her SpO<sub>2</sub> above 94 percent. Despite readings in the 87 to 88 percent range,

the nurse failed to inform the physician despite urging by the respiratory therapist. The court found the hospital negligent.

*Case 3* — In 1989, personnel were found negligent because they failed to monitor the postoperative course of a two-year-old girl in the recovery room with pulse oximetry, after she had experienced an episode of apnea. The child subsequently suffered a cardiac arrest and massive central nervous system damage. The family was awarded \$1,400,000.

#### **Caregiver competence and education issues**

The skill level of caregivers who respond to pulse oximetry alarms is an additional source of institutional liability. Pulse oximetry has been used by respiratory therapists, physicians, and specially trained nurses for the evaluation of perceived hypoxemia. These clinicians possessed knowledge of the technology's limitations in evaluating tissue hypoxemia, the specific techniques required to obtain accurate results, and advanced clinical assessment skills to validate the accuracy of SpO<sub>2</sub> data.

The indications for the application of pulse oximetry as urged by the published standards of care have exploded in the clinical setting. The FORUM perceives that this simple technique is being used as a screening tool by any and all who may obtain and document vital signs for interpretation by other health professionals. The prevailing training regimen for pulse oximetry seems to be "see one, do one, teach one," often resulting in erroneous assessments because

of improper sizing of sensors, poor alignment, poor clinical correlation, and, sometimes, inappropriate application (such as on patients with conditions such as severe anemia or carbon monoxide poisoning).

Assistant-level caregivers, such as patient care technicians, possess limited patient assessment skills and must defer clinical judgment to the patient's nurse. On a general care unit, frequent alarms may require that these assistants respond, which poses the risk of the alarms being silenced without a clinical assessment of the patient being performed.

In 1996, the Ohio Respiratory Care Board ruled on two occasions regarding the skill level of personnel using pulse oximetry. In the first case, the board directed that reapplication of pulse oximeter sensors by an unlicensed caregiver was appropriate only if a licensed health care worker was notified so that the reapplication could be checked. In the second case, the board stated that pulse oximetry involves more than the simple act of placing a monitor on a patient and recording a reading.

To appropriately guarantee the accuracy of pulse oximetry data and use the results obtained to assess a patient's oxygenation, the caregiver must assess and relate the patient's clinical appearance, other clinical data, and the environment. This responsibility cannot be deferred to untrained and inexperienced assistants.

The use of continuous pulse oximetry monitoring without documented clinical intervention is also concerning. One FORUM hospital's quality

assurance data from 116 days of surveillance of pulse-oximetry practices is compelling. The data revealed that on 48 percent of those days, physicians did not record SpO<sub>2</sub> values in the medical record for patients on general care units; and on 52 percent of those days, no specific action was taken when the documented SpO<sub>2</sub> was outside the prescribed limits.

**The need for coordination**

Decentralized departments within hospitals operate under independent management. Decisions on capital purchases, supplies, and practice policies have not been coordinated among individual managers and have resulted in increased expense that may be avoidable, at least in part. FORUM participants have reported incidents of care units with idle pulse oximeters while other units were renting pulse oximeters to meet their peak demands. Inconsistent clinical practice policies may interfere with cost savings if the patient is moved from a care unit where permanent sensors are used to one where disposable sensors are applied.

Some care units may participate in a sensor recycling program, whereas other units choose not to participate. Billing practices for pulse oximetry also vary among care units and among the caregivers performing the monitoring.

Following a 1996 meeting of the FORUM, the following recommendations for the use of pulse oximetry in FORUM institutions that care for pediatric patients was adopted.

*Hospitalwide policy for pulse*

*oximetry* — Institutions assume an enormous financial and legal responsibility for the well being of patients under their care. Judgments have been awarded against institutions found to be negligent in cases involving pulse oximetry. A hospitalwide policy for the clinical application of pulse oximetry should be developed by each institution that incorporates published clinical standards, including those of the Joint Commission on Accreditation of Healthcare Organizations.

If patients are to be continuously monitored with pulse oximetry outside a directly attended or critical care unit, they should be placed in a location where alarms can be heard and responded to in an appropriate and timely manner. If the need for pulse oximetry monitoring on a general care unit is high because patients are more seriously ill than usual or because the general care unit is being used for critical care unit overflow, a central monitoring station may be necessary.

*Multidisciplinary oversight* — The FORUM strongly encourages institutions to create a multidisciplinary committee (or a position, department, service line) comprised of appropriate personnel to manage pulse oximetry services. This committee would review hospitalwide capital, rental, and supply costs and evaluate unit-specific expense to identify cost-saving opportunities. Other committee functions might be to standardize monitor and sensor inventory, coordinate capital distribution, and evaluate patient flow patterns through the institution

to determine possible cost-reduction strategies. New equipment evaluation, educational competencies and training strategies, and clinical utilization policy development/review would be under the committee's purview.

A multidisciplinary committee would have comprehensive management authority and accountability — horizontally among all departments and service lines and vertically among the purchasers, clinical/technical specialists, and users.

*Manufacturer support* — Manufacturers could offer support for an institution's pulse oximetry service by providing a comprehensive needs assessment to assist the management committee in determining the appropriate equipment and supplies. Opportunities for cost savings should also be included. Such assistance is already available from one manufacturer.

*Effective clinical application by trained, competent caregivers* — Clinical policies should reflect clinical indications and institutional utilization guidelines for clinicians' education and reference. Utilization policies must reflect concerns for patient safety, acknowledge clinical limitations and restrictions of the physical plant, and adhere to published standards.

The technical aspects of pulse oximetry, particularly application and troubleshooting, should also be addressed. Specific monitor and sensor options for each clinical unit should be defined to promote best practice and cost control.

Data from any monitor should serve as an adjunct to, rather than a replacement of, clinical judgment. Only a well-trained clinician, regardless of specific training, is prepared to assess data from a monitor. The FORUM believes that this approach, combined with improved management of technology resources, can provide both more effective patient care and a substantial reduction in costs.

The implication that pulse oximetry is superior to clinical judgment is serious indeed.<sup>13</sup> Any monitor must be truly monitored, and clinical personnel who can respond most effectively must be available when any monitor is used. The FORUM does not object to the application of the sensor itself by unlicensed personnel who have been properly trained and are adequately supervised. However, only those qualified by experience and training should interpret the data. The perception of safety afforded by continuous monitoring of any vital function cannot be ethically or fiscally justified in the absence of clinical indications and a trained caregiver's attention.

Caregivers who are responsible for using pulse oximetry must be educated as to the proper set up, alarm capabilities, technical limitations, and clinical appropriateness of each type of monitor used. They must be aware of the sensor choices within their institution and be able to demonstrate proper sizing of sensors to achieve the emitter-detector alignment necessary for measuring SpO<sub>2</sub>.

In summary, ensuring caregiver competence through education and skills validation will promote

accurate measurement, improve clinical decision making, and increase the value of pulse oximetry in caring for sick children.

*Clinical utilization recommendations* — In 1993, the Society of Critical Care Medicine published its technology assessment of pulse oximetry. It stated that the appropriate clinical uses of pulse oximetry fall into two broad categories: as a warning system based on continuous real time measurement of arterial desaturation or as an end-point for titration of therapeutic interventions.<sup>15</sup>

Based on its experiences, the FORUM believes that pulse oximetry monitoring should be regarded in terms of an end-point measurement when used for a patient outside an ICU. The dis-

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tinction is important because a continuous monitor requires continuous surveillance, whereas an end-point measurement does not. The application of a continuous pulse oximeter to a patient, if the displayed readings or alarms are not observed and responded to in a timely manner, does not add clinical value or enhance patient safety.

*Logistics and management recommendations* — The following are practical suggestions offered by the FORUM and address some everyday problems with the implementation of pulse oximetry on general care units.

- If continuous pulse oximetry is used on general care units, patients must be in rooms near the nursing station where alarms can be heard.
- If a patient is active, another type of monitoring should be considered to avoid multiple nuisance alarms and possible desensitization of the clinical staff.
- If a patient is on an apnea or cardiac monitor, spot checks would be more appropriate than continuous monitoring.
- Physicians should document the reason for using continuous pulse oximetry on patients breathing room air.
- Regardless of the type or location of pulse oximetry monitoring, caregivers should make sure that family members who remain at the bedside of their

child understand the purpose of the monitor and know how to respond to the alarms or concerns about the displayed values. Caregivers should respect their reports of concern and annoyance and respond to them promptly.

- Clinicians — respiratory therapists and nurses — must learn how to respond to inappropriate physician orders for pulse oximetry in all hospital care units. They must understand the technical theory and limitations of pulse oximetry and be prepared to respond to concerns of family members promptly and appropriately.

**Clinical pathways and protocols**

Clinical practice guidelines, clinical pathways, and protocols have been developed in many health care disciplines to promote better management of patients with specific diseases and those in specific care units (for example, in the operating room), and to define appropriate utilization of available services.


Participants in the FORUM discussed how pulse oximetry could be incorporated into clinical pathways, recognizing that patients with certain serious respiratory disorders cared for outside the ICUs are at risk for respiratory failure and hypoxemia. The FORUM believes that the severity of a patient's illness and the results of an initial assessment are the most clinically sound determinants for pulse oximetry application, not diagnosis alone. In caring for children, health care professions must discriminate impending respiratory failure from transient hypoxemia among patients with respiratory distress.

Several FORUM hospitals have implemented clinical protocols for assessing the severity of respiratory illness and to determine the frequency of aerosol therapy and other clinical interventions. A similar objective system could be used to determine a patient's risk for impending respiratory failure and hypoxemia and to suggest the appropriate type and frequency of SpO<sub>2</sub> measurement.

**Ensuring the best care for sick children**

The goal of the FORUM is not to dictate specific practices for the use of pulse oximetry in

its member institutions but rather to stimulate awareness of the issues and provide recommendations for appropriate use of pulse oximetry for pediatric patients. Recommendations are based on current standards and guidelines, as well as the experiences of the FORUM members. Our desire is to improve the quality of patient care and reduce costs.

Today's health care environment demands that caregivers, administrators, hospitals, and industry be vigilant in evaluating the use of pulse oximetry, as well as other technology, and adhere to reasoned judgment and clear evidence in its application. 

**FOOTNOTES**

- \* 1996 data
- † Legal research provided by Eugene R. Butler, JD, RRT, Columbus, OH

**EDITOR'S NOTE**

Editorial assistance for this article was provided by Kaye Weber, MS, RRT, of Dallas, TX, former associate editor of RESPIRATORY CARE, the AARC's science journal.

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