CHAPTER 5

MONITORING THE EMERGENCY PATIENT

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PERSPECTIVE

Monitoring is a routine part of emergency department (ED) care. From vital sign measurement to the provision of critical care, monitoring physiologic function provides clinicians with potentially relevant clinical information as a “snapshot” in time or in continuous fashion. In the former case, it allows for screening and triage, and in the latter, it allows for ongoing evaluation of response to treatment or changes in clinical condition.

This chapter focuses on the following monitoring modalities: noninvasive blood pressure measurement, pulse oximetry, and ventilation monitoring and the use of end-tidal carbon dioxide (ETCO₂) measurement. Fetal monitoring after trauma and cerebral function monitoring are also briefly discussed.

NONINVASIVE BLOOD PRESSURE MEASUREMENT

Blood pressure measurement by sphygmomanometer is the most common method of noninvasively measuring arterial pressure by indirectly measuring systolic, diastolic, mean arterial pressure, and pulse pressure. The pulse pressure closely represents the interplay of cardiac output and overall systemic vascular resistance, making it an important screening and monitoring tool in ED patients.

Traditional blood pressure measurement by sphygmomanometer can be obtained by Doppler, palpation, auscultation, and oscillometric methods. Palpation allows for only systolic pressure determination, is time and resource intensive, and generally is used only in noisy environments (such as emergency medical services [EMS] transport) where measurement by oscillometric means may be difficult. Doppler is particularly helpful in identifying the presence of a systolic pulse in hypotensive individuals or in internally (i.e., atherosclerosis) or externally (i.e., compartment syndrome) flow-limited extremities. Auscultation, otherwise known as “manual” blood pressure measurement, remains a common, reliable, and reproducible method of blood pressure measurement 100 years after the Korotkoff technique was discovered. This method relies on placing the stethoscope at the antecubital fossa, inflating the blood pressure cuff, and recording the pressure at which auscultation of the pulse returns (the systolic blood pressure) and when it disappears (the diastolic blood pressure). Auscultation is generally considered to underestimate the systolic blood pressure and overestimate the diastolic pressure. Although accuracy has improved with standardization of the technology, this technique is occasionally prone to significant inaccuracy. The oscillometric technique measures oscillations in the pressure during deflation of the cuff; the maximal point of oscillation represents the mean arterial pressure. This is the most common noninvasive method of measuring blood pressure in the ED, commonly called the “automatic” blood pressure. This method has several advantages over auscultation, including less susceptibility to noise, the lack of necessity for specific placement of a transducer over the artery, less resource usage, regular measurement intervals, and the ability to embed readings into other clinical monitors. Comparisons of auscultation and oscillometric measurement with intra-arterial measurement have found good agreement (mean percent error ≤3%). Cuff-based blood pressure measurement is limited by technique and clinical circumstances. The quality of the device, cuff size, body positioning, and arm positioning are all components of the measuring technique that can affect the accuracy. Clinical circumstances such as obesity, dysrhythmias, and extremes of age (young children and elderly) may also affect the accuracy. The ease of use of oscillometric blood pressure measurement makes this modality ideal for ED noninvasive monitoring.

Other methods of providing continuous, noninvasive blood pressure monitoring often rely on partial radial artery compression or arterial loading counterpressure and offer results comparable to those of an arterial catheter with the benefit of added mobility. Newer continuous, noninvasive blood pressure monitors have the advantage of providing additional advanced hemodynamic measures, such as stroke volume and cardiac output, which may be beneficial in critically ill patients.

The gold standard, and the most accurate method of measuring blood pressure, remains the intra-arterial catheter. The combination of the invasiveness of this method and the low but real risk of arterial injury or thrombosis makes its use infrequent. However, such monitoring is becoming more frequent in EDs when there are no available intensive care unit beds and prolonged resuscitation is carried out in the ED. Arterial monitoring is also increasingly a part of aggressive resuscitation management protocols in the ED. Common situations in which invasive arterial monitoring may be of benefit include (1) anticipated hemodynamic instability, (2) monitoring of conditions or treatments that result in large fluid or blood pressure shifts, (3) frequent arterial blood sampling, and (4) expected inaccuracies in noninvasive blood pressure management (e.g., because of obesity or dysrhythmias).

PULSE OXIMETRY

Pulse oximetry is widely used for ED and out-of-hospital patient monitoring. It provides a real-time assessment of the effectiveness
of interventions and disease progression as related to oxygenation. Its use has become so widespread as both a screening and monitoring tool that it is frequently regarded as the “fifth vital sign.”

Pulse oximetry is based on the essential premise of the Beer-Lambert law that the concentration of an absorbing substance can be determined if the characteristic wavelength of that substance, the intensity of the light transmitted through the substance, and the distance of transmission are known. Device design accounts for the intensity of light and the transmission distance. Two light-emitting diodes (LEDs) give off light at wavelengths characteristic of oxyhemoglobin and deoxyhemoglobin (660 nm and 940 nm). Absorption characteristics of tissue, arterial blood, and venous blood are generally static over a cardiac cycle. Therefore through measurement of transmitted light several hundred times per second, the beat-to-beat alternations that occur in pulsatile blood can be isolated and the static components filtered out. The fractional difference between the two wavelengths is measured and reflected in the pulse oximetry.

Pulse oximetry measures the percentage of arterial hemoglobin that is in the oxyhemoglobin state. It reflects the amount of oxygen that hemoglobin is carrying as a percent of the maximum it can carry; this is commonly referred to as the percent arterial oxygen saturation (SaO₂). Pulse oximetry does not measure the partial pressure of oxygen in the blood (PaO₂); however, SaO₂ represents by far the larger reservoir of blood. Nonetheless, an awareness of the relationship between the two measures is important, as one main advantage of pulse oximetry is to obviate the need for multiple samples for arterial blood gas measurement. The relationship between SaO₂ and PaO₂ is described by the oxyhemoglobin dissociation curve. Although the two measures correlate well, their relationship is nonlinear. Users should be aware that large changes in the SaO₂ occur with small changes in the PaO₂ in hypoxic patients, but this is generally not of concern because pulse oximeters are generally accurate between 80% and 100%. Below this range, the role is reversed, and large changes in PaO₂ may occur with small changes in SaO₂. Pulse oximetry retains its usefulness because clinically important hypoxia exists regardless of whether the pulse oximeter is reading 85% or 65%. Measurements can be made on the ears or fingers, although the fingers are generally better in patients with poor perfusion.

Early ED use of pulse oximetry came through extrapolation from anesthesiology literature, which demonstrated less frequent and shorter episodes of desaturation and earlier recognition of hypoxia during or after anesthesia. In the ED, pulse oximetry is largely used in initial triage of patients, particularly those with cardiopulmonary complaints, or in the monitoring and management of patients who are sedated or critically ill, particularly with respiratory distress or during endotracheal intubation. In the latter case, pulse oximetry has been shown to reduce the frequency of hypoxic episodes. SaO₂ values at or below 96% have been shown to be 100% sensitive for detection of hypoxia (PaO₂ < 70 torr), but such a cutoff can be different in patients with obstructive lung disease.

Pulse oximetry has several important clinical limitations. By design, pulse oximetry measures only two wavelengths. At these wavelengths, traditional pulse oximeters are unable to distinguish oxyhemoglobin and deoxyhemoglobin from two other important dyshemoglobinemia: methemoglobin (MetHb) and carboxyhemoglobin (COHb). Multiwavelength CO-oximeters are now available that can distinguish the four wavelengths. Oxygen saturation by pulse oximetry will be equivalent to actual saturation, presuming insignificant amounts of MetHb and COHb exist in the blood. In the setting of MetHb or COHb exposure, the pulse oximeter will read falsely elevated levels of SaO₂ even at relatively high exposures. In heavy smokers, COHb levels of 3 to 15% can commonly be found, but this has little impact on the accuracy of the SaO₂. Although signal artifact is probably the most common technical limitation to adequate measurement, other limitations include low perfusion and therefore low pulsatile component, ambient light, deep skin pigmentation, methylene blue, and nail polish. Averaging saturation measurements over several seconds limits the impact of motion artifact and improves the accuracy.

SpO₂ (oxygen saturation as measured by pulse oximetry) may obviate the need for repeated, invasive arterial sampling to determine oxygen saturation (and to some degree PaO₂), but it does not adequately provide insight into pH or partial pressure of carbon dioxide (Paco₂). More important, SaO₂ does not aid in determining the adequacy of ventilation when significant hypercapnia may precede hypoxia and supplemental oxygen may mask hypoventilation. For this situation, one needs ventilation monitoring through ETCO₂ measurement.

**END-TIDAL CARBON DIOXIDE MONITORING**

The concentration of carbon dioxide (CO₂) in an exhaled breath is intrinsically linked to tissue metabolism, systemic circulation, and ventilation. Capnography is the graphic record, represented as a waveform, or capnogram, of the instantaneous CO₂ concentrations in respired gases during a respiratory cycle. Capnography provides continuous, real-time, breath-to-breath feedback on the clinical status of the patient, allowing the clinician to determine the baseline ventilatory status and to track changes over time. Capnography is also a diagnostic monitoring modality because certain disease conditions are associated with characteristic waveforms. Although the concentrations of CO₂ can be displayed continuously throughout the respiratory cycle, by convention only the maximum CO₂ concentration at the end of each tidal breath, the ETCO₂, is ordinarily displayed. Capnometry is the quantitative measurement of ETCO₂, displayed as a number without a waveform. Colorimetric detectors use color scales to estimate ranges of ETCO₂ but are not sufficiently accurate to give quantitative measurements. Their use is therefore limited to confirmation of correct endotracheal tube (ETT) placement and its continuous location in the trachea. Although originally used during general anesthesia in the operating room, ETCO₂ monitoring has now become a standard monitoring modality in the ED and nonhospital medical setting.

CO₂ monitors are configured as either sidestream or mainstream, depending on the location of the photoelectric detector or sensor. Mainstream devices measure CO₂ directly from the airway, with the sensor attached directly to the ETT. Sidestream devices, more commonly used by EMS personnel and in the ED, aspirate a sample of gas through tubing into a sensor located inside the monitor and are used for both intubated and nonintubated patients. They are lightweight and may be integrated into nasal cannulae that simultaneously sample CO₂ and deliver low-flow oxygen, allowing for continuous oxygen delivery during procedural sedation and analgesia.

Colorimetric CO₂ detectors use pH-sensitive filter paper impregnated with metacresol purple, which changes color from purple (<4 mm Hg CO₂) to tan (4-15 mm Hg CO₂) to yellow (>20 mm Hg CO₂) depending on the concentration of CO₂. (See Chapter 1.) The indicator, housed in a plastic casing, is inserted between the ETT and the ventilator bag and detects changes on a breath-by-breath basis. These detectors are also inexpensive and easy to use and should be available in every ED and on every EMS unit that performs intubation for confirmation of ETT placement if capnography or capnometry is not available.

In patients with normal cardiopulmonary function, there is a close correlation between alveolar CO₂ (Paco₂) and arterial CO₂...
(Paco₂). The ETCO₂ is usually 2 to 5 mm Hg less than the Paco₂ because of the dilution of the end-tidal gases by physiologic dead space gas. Conditions that affect ventilation-perfusion ratios (including pulmonary embolism), cardiac arrest, hypovolemia, obstructive lung disease, and the lateral decubitus position can widen the Pa-ETCO₂ gradient. Several recent studies, however, have shown high concordance between ETCO₂ and Paco₂ in adult asthmatics and in children with moderate and severe respiratory distress from bronchiolitis, asthma, and pneumonia. Although ETCO₂ may not accurately reflect the absolute Paco₂ in critically ill patients, it is still valuable in detecting ventilatory trends and identifying sudden airway events.

Analysis of the shape of the capnogram can yield valuable diagnostic information. A normal capnogram has four phases (Fig. 5-1A). Phase 1-2 represents a CO₂-free portion of the respiratory cycle. Most often this is the inspiratory phase, although it may represent apnea or a disconnection of the device from the patient. An elevation of this baseline above zero implies rebreathing of CO₂, as in increased dead space in the circuit or contamination of the sensor.

Phase 2-3, the rapid upstroke of the curve, represents the transition from inspiration to expiration and the mixing of dead space and alveolar gas. Phase 3-4, the alveolar plateau, represents the predominance of CO₂-rich alveolar gas in the breath stream and tends to slope gently upward with the uneven emptying of alveoli. Point 4 (the ETCO₂) represents the maximum CO₂ concentration in each breath and is the number that appears on the monitor. The slope of this phase can be increased by the same obstructive factors that increase the slope of phase 2-3 and is also a normal physiologic variation in pregnancy. A dip in the plateau indicates a spontaneous respiratory effort during mechanical ventilation, as in hypoxia, hypercarbia, or inadequate anesthesia (Fig. 5-1C).

Phase 4-5, the inspiratory downstroke, is a nearly vertical drop to baseline. This slope can be prolonged and blend in with the expiratory phase in endotracheal cuff leaks (Fig. 5-1D). Abnormal respiratory patterns that are fast or chaotic limit the usefulness of ETCO₂ monitoring because characteristic waveform patterns are difficult to discern.

Capnography is used in the ED in many intubated and non-intubated clinical scenarios. It is an extremely valuable monitoring modality for intubated patients, providing information regarding respiratory function and immediate notification of accidental extubation. It can be used to confirm ETT placement in the trachea, continuously monitor tube position in the trachea during transport, provide qualitative and quantitative methods of assessing cardiac output, gauge effectiveness of cardiopulmonary resuscitation (CPR) during cardiac arrest, determine prognosis in CPR and in trauma, maintain appropriate ETCO₂ levels in patients with elevated intracranial pressure, estimate Paco₂ in patients with normal lung function, assess response to treatment in patients with acute respiratory distress, determine adequacy of ventilation in patients with altered mental status (including drug-induced alterations in consciousness during procedural sedation and analgesia), assess ventilatory status of actively seizing patients, and help detect metabolic acidosis.

Along with visualizing tracheal rings on bronchoscopy, capnography is the other gold standard used to confirm intubation of the trachea (see Chapter 1). Misleading ETCO₂ readings can occur with esophageal intubation after bag or mask ventilation and ingestion of carbonated beverages or antacids. However, detection of ETCO₂ usually ceases after six breaths, and if capnography is used, the waveform, which initially appears normal, progressively becomes smaller, losing height until it disappears (flatline) by the sixth breath. ETCO₂ is also falsely elevated for 5 to 10 minutes after injection of sodium bicarbonate. Capnography can confirm intubation of the trachea but may give false-negative results in cardiac arrest if delivery of CO₂ from the periphery to the lungs is sufficiently diminished. In these situations, it is difficult to determine whether the absence of the
waveform is a result of esophageal intubation or poor pulmonary blood flow. In nonarrest settings the ET\textsubscript{CO}\textsubscript{2} has 100% sensitivity and specificity in confirming correct tube placement and is also useful for monitoring for accidental tube dislodgement.

Airway, breathing, and circulatory assessment of critically ill or injured patients can be rapidly determined through use of ET\textsubscript{CO}\textsubscript{2} values and the capnogram.\textsuperscript{25} The presence of a normal capnogram denotes a patent airway and spontaneous breathing, and normal ET\textsubscript{CO}\textsubscript{2} levels indicate adequate ventilation and perfusion. Capnography can therefore be used to assess critically ill patients (including victims of chemical terrorism with nerve gas exposure) and patients who are actively seizing.\textsuperscript{25,26} Unlike pulse oximetry and electrocardiography, capnographic measurement is airway based and therefore is not subject to motion artifact. It also provides reliable readings in low-perfusion states.

Animal and human studies have shown that ET\textsubscript{CO}\textsubscript{2} is a useful noninvasive measurement that is highly correlated with cardiac output and is the earliest indicator of return of spontaneous circulation (ROSC) in CPR.\textsuperscript{27,28} ROSC is heralded by an almost immediate increase in ET\textsubscript{CO}\textsubscript{2} from baseline. Multiple studies have shown that ET\textsubscript{CO}\textsubscript{2} has prognostic value in terms of mortality during CPR.\textsuperscript{27-32} No patient with a mean ET\textsubscript{CO}\textsubscript{2} less than 10 mm Hg after 20 minutes of CPR has survived, giving ET\textsubscript{CO}\textsubscript{2} measurement a high negative predictive value for failure of resuscitation. Despite these promising findings, capnography requires further prospective validation to confirm its usefulness as a prognostic tool in cardiac arrest.

Capnography is the only ventilation monitoring modality that is accurate and reliable in patients with active, generalized seizures.\textsuperscript{25,26} Capnographic data (capnogram, ET\textsubscript{CO}\textsubscript{2}, respiratory rate) can be used to distinguish among actively seizing patients with apnea (flatline waveform, no ET\textsubscript{CO}\textsubscript{2} readings, and no chest wall movement), ineffective ventilation with low–tidal volume breathing (small capnograms, low ET\textsubscript{CO}\textsubscript{2}), and effective ventilation (normal capnogram, normal ET\textsubscript{CO}\textsubscript{2}).

Capnography can also rapidly detect the common airway, respiratory, and central nervous system complications associated with the nerve agents in chemical terrorism, including apnea, upper airway obstruction, laryngospasm, bronchospasm, and respiratory failure.\textsuperscript{15,25}

Capnography provides dynamic monitoring of ventilatory status in patients with acute respiratory distress, such as from asthma, bronchitis, chronic obstructive pulmonary disease (COPD), congestive heart failure, and cystic fibrosis. By measuring ET\textsubscript{CO}\textsubscript{2} and respiratory rate with each breath, capnography provides instantaneous feedback on the clinical status of the patient. Respiratory rate is measured directly from the airway via nasal/oral cannulae, providing a more reliable reading than impedance respiratory monitoring. In upper airway obstruction and laryngospasm, for example, impedance monitoring detects chest wall movement, interprets this as a valid breath, and displays a respiratory rate, even though the patient is not ventilating. In contrast, capnography detects no ventilation and shows a flatline capnogram.

Bronchospasm in obstructive lung disease leads to upward slanting of the expiratory plateau of the capnogram (Fig. 5-2, middle panel). Changes in ET\textsubscript{CO}\textsubscript{2} over time and the slope of this phase of the capnogram have been shown to correlate well with spirometric measurements (forced expiratory volume in 1 second [FEV\textsubscript{1}] and peak expiratory flow rate [PEFR]).\textsuperscript{33-35} Capnography has the advantage of being independent of effort, gender, age, and height and is a useful objective measure in asthmatic patients who are unwilling or unable to cooperate with spirometry (e.g., young children, ventilated patients, and patients in acute respiratory distress). Capnography can also be used to distinguish obstructive from restrictive lung disease.\textsuperscript{38} Characteristic capnographic patterns associated with restrictive and obstructive lung disease are shown in Figure 5-2 (bottom panel).

Capnography can also detect the common adverse airway and respiratory events associated with procedural sedation and analgesia (see Chapter 4).\textsuperscript{15} Both central and obstructive apnea can be almost instantaneously detected by capnography.\textsuperscript{15} Capnography is the earliest indicator of airway or respiratory compromise and displays an abnormally high or low ET\textsubscript{CO}\textsubscript{2} 5 to 240 seconds before pulse oximetry detects a falling oxyhemoglobin saturation, especially in patients receiving supplemental oxygen.\textsuperscript{36,37} Low ET\textsubscript{CO}\textsubscript{2}—that is, hypopneic hypoventilation—is commonly seen with sedative-hypnotic agents (especially propofol) and during deep sedation, represents low–tidal volume breathing (airway dead space remains constant but tidal volume decreases), and should not be misinterpreted as hyperventilation.\textsuperscript{15,38}

Capnography appears to be more sensitive than clinical assessment of ventilation in the detection of apnea. Soto and colleagues found that during procedural sedation 10 of 39 patients (26%) experienced 20-second periods of apnea that were detected by capnography but not by the clinicians.\textsuperscript{39}

Two recent randomized controlled trials on the use of capnography during procedural sedation demonstrated that use of capnography decreases hypoxia and allows for delivery of supplemental oxygen during sedation without affecting the accuracy of ventilatory monitoring.\textsuperscript{37,40} Both studies had the same design (two groups; standard monitoring blinded to capnography vs. standard monitoring and capnography) and the same outcome measure (hypoxia rate during sedation). The first study found a hypoxia rate of 42% in the no-capnography group and a rate of 25% in the capnography group. All patients with hypoxia exhibited capnographic changes before the hypoxic event. The second study found similar results: a hypoxia rate of 69% in the no-capnography group and 46% in the capnography group. The apnea rate was also significant: 62% in the no-capnography group and 41% in the capnography group.

Obtunded or unconscious patients, including those with alcohol intoxication, intentional or unintentional drug overdose, and postictal patients (especially those treated with benzodiazepines), may have impaired ventilation. Capnography can differentiate between postictal patients with effective ventilation and those with ineffective ventilation, as well as providing continuous monitoring of ventilatory trends over time to identify those patients at risk for respiratory depression and respiratory failure.
representing electroencephalographic silence and 100 a fully awake adult.35

BIS monitoring has been studied in the ED in an attempt to objectify sedation endpoints by titrating to a target BIS score.44-46 However, the evidence of its ability to reliably reflect depth of sedation is conflicting. More important, the threshold beyond which ventilatory compromise occurs has not been determined, further limiting the usefulness of routine BIS monitoring for sedation in the ED.44-46 A recent study found that BIS monitoring reliably distinguished patients undergoing procedural sedation and analgesia who were sedated to the point of general anesthesia from those with lesser degrees of sedation but did not discriminate mild-to-moderate sedation from moderate-to-deep sedation.46 The findings of Miner and coauthors supported this contention in that the assignment of a preprocedural BIS target sedation level of moderate or deep procedural sedation did not influence the level of sedation achieved, the rate of respiratory depression, the occurrence of complications, the time to return of baseline mental status, or the success of the procedure. They concluded that the assignment of a preprocedural target sedation level was not an effective means of changing the outcome of procedural sedation in the ED.47

Two small pediatric ED studies found that BIS monitoring correlated with clinical sedation scores for nondissociative agents44,48 but not ketamine. Determination of usefulness and effectiveness on outcome for children undergoing procedural sedation and analgesia awaits larger trials.

Another technology that monitors cerebral function is cerebral oximetry. Cerebral tissue oxygenation (i.e., regional oxygen saturation, \( rSO_2 \)) is measured by near-infrared spectroscopy monitoring of the nonpulsatile signal component, reflecting tissue circulation of cerebral vasculature. This technology has been primarily studied in the operating room, with one ED study during procedural sedation showing poor correlation among changes in cerebral oximetry, pulse oximetry, and capnography.49

**FETAL MONITORING**

A small but significant percentage of all pregnancies (6-7%) are complicated by traumatic and/or accidental injury.50 Trauma represents the leading nonobstetric cause of death and carries a mortality rate of 6 to 7%.51 Whereas the majority of injuries are related to motor vehicle accidents, other common causes include assaults, domestic abuse, and falls. Uterine contractions occur in almost 50% of patients, although preterm labor and preterm delivery are difficult to predict after trauma. As a result, the Eastern Association for the Surgery of Trauma recommendations include cardiotocographic monitoring for a minimum of 6 hours after trauma in women at more than 20 weeks’ gestation. In addition, peripartum complications and early preterm birth are difficult to predict after trauma. As a result, the Eastern Association for the Surgery of Trauma recommendations include cardiotocographic monitoring for a minimum of 6 hours after trauma in women at more than 20 weeks’ gestation. In addition to serial examination, such fetal monitoring allows for the identification of uterine contractions and nonreassuring heart rate changes. Clinically concerning heart rate patterns can include persistent fetal tachycardia, bradycardia, loss of baseline variability, or late decelerations.

Although the optimal period of monitoring has not been determined, further monitoring is recommended when such abnormalities are identified or serial examination findings warrant it. Emergency physicians are generally trained and capable of recognizing such cardiotocographic findings, but availability of such monitors in the ED is variable. ED bedside ultrasonography is more commonly available and can demonstrate fetal heart rate and movement. However, ultrasonography requires intermittent examinations, has limited ability to track fetal heart tones, and is unable to measure uterine contractions.

**CEREBRAL FUNCTION MONITORING**

The Bispectral Index (BIS) is used to monitor, analyze, and process a patient’s electroencephalogram during sedation to produce a single number—the BIS score. This unitless number, ranging from 0 to 100, is used as an indicator of the depth of sedation, with 0
Monitor Alarms and Limits

Continuous vital sign monitoring, with alarm thresholds that notify staff regarding changes in physiologic conditions, has become a routine part of ED care. Although these alarms are designed to be highly sensitive, their lack of specificity has the potential to desensitize staff and reduce alarm effectiveness in identifying important changes in the clinical condition (i.e., “nuisance alarms”). Continuous monitoring in select patient populations, such as those with low-risk chest pain, has limited usefulness, with less than 1% of alarms resulting in a change in clinical management.52,53 A multidisciplinary team-based approach that focuses on identifying optimal application of monitoring, standardizing alarm limits and the staff response, and using improved alarm technology has the potential to improve patient safety and enhance workplace efficiency and satisfaction.54

The references for this chapter can be found online by accessing the accompanying Expert Consult website.