As medical practice and technology has advanced over the years, more and more premature infants are surviving to be discharged to the home. These infants have, for the most part, been very reliant on technology during their stay in the neonatal intensive care unit (NICU). Dependent on local practice, most infants are typically discharged at or near their expected due date. Most make this transition to the home setting without the need for transitional technology, such as a home apnea monitor. For some, recurrent apnea events may cause concern among family and hospital caregivers regarding the child’s readiness for discharge.

The use of home apnea monitoring has been around for almost 20 years, and advances in technology have helped improve the quality of monitoring. In 1988, a paper published by Nuttall stated that home apnea monitoring was the prototype for the use of other medical technologies in the home, allowing parents to become the caregivers.1

Home apnea monitoring grew out of the suspected relationship of apnea and sudden infant death syndrome (SIDS). Currently there is much controversy as to the validity of this concept. In 1993, Keens and Ward summarized that the National Institute of Child Health and Human Development collaborative epidemiological study of SIDS showed no difference in the incidence of neonatal apnea in SIDS victims compared to non-SIDS controls. The study did find an increased incidence of apparent life threatening event (ALTE) occurring post-term in SIDS victims (7 percent) than in non-SIDS controls (3 percent). However, 93 percent of SIDS victims had no apnea observed prior to death.

Home apnea/bradycardia monitoring and infant apnea evaluations have not substantially decreased the SIDS rate for the general population. SIDS may still be attributed to a respiratory disorder, but the simplistic approach of treating apnea in infants has not resulted in substantial decreases in SIDS.2

Home apnea monitoring involves the use of an apnea monitor to detect apnea events. If the monitor detects an event it considers as an apnea event, an alarm will sound alerting the caregiver that observation and intervention may be needed. Many conditions may cause false alarms; but still observation, assess-
In 1986, a consensus statement on infant home apnea monitoring issued by the National Institutes of Health recommended apnea monitoring for certain groups of infants at risk for SIDS. This group includes those with low birthweight and apnea and siblings of infants with SIDS after a second SIDS death in the family. Major indications for infant home apnea monitoring include an infant who is premature but has symptoms of idiopathic apnea of prematurity although otherwise ready for discharge from the hospital, infants with a history of an ALTE requiring resuscitation or vigorous stimulation for which no cause has been identified, and infants with a condition having an inherent risk of recurring apnea.3

What is an apnea event?

Most literature defines an apnea event lasting for more than 20 seconds and associated with such cardiovascular and neurophysiologic changes as cyanosis and loss of muscle tone or rigidity. The decrease in oxygen saturation levels incurred during these events can cause significant serious health consequences for affected infants. Respiratory pauses are of clinical significance because infants have a higher rate of oxygen consumption, lower oxygen stores, and smaller lung volumes. The infant is more sensitive and vulnerable to a lack of oxygen.

Apnea events need to be differentiated from the more common periodic breathing pattern found in premature infants. Periodic breathing is defined as a respiratory pattern that has cyclic brief pauses of 5–10 seconds that are followed by bursts of respiration at a rate of 5–60 a minute within a time frame of 10–15 seconds. Periodic breathing is not associated with cyanosis or changes in heart rate.

Definitions of Apnea

Apnea: The cessation of respiratory airflow. The respiratory pause may be central or diaphragmatic (that is, no respiratory effort), obstructive (usually caused by upper airway obstruction), or mixed. Short (15 seconds) central apnea can be normal for all ages.

Pathologic Apnea: Occurs for longer than 20 seconds or is associated with cyanosis, abrupt marked pallor, hypotonia, or bradycardia.

Periodic Breathing: A breathing pattern in which there are three or more respiratory pauses of greater than three seconds duration with less than 20 seconds of respiration between pauses. Periodic breathing can be a normal event.

Apnea of Prematurity (AOP): Period breathing with pathologic apnea in a premature infant. Apnea of prematurity usually ceases by 37 weeks gestation but occasionally persists to several weeks past term.

Apparent Life Threatening Event (ALTE): An episode that is characterized by some combination of apnea, color change, marked muscle tone change, choking, or gagging.

Apnea of Infancy (AOI): An unexplained episode of cessation of breathing for 20 seconds or longer, or a shorter respiratory pause associated with bradycardia, cyanosis, pallor, or marked hypotonia. The infants are usually older than 37 weeks gestational age at onset of pathologic apnea. The term is reserved for infants for whom no specific cause of ALTE can be identified.

SOURCE: National Institutes of Health, Infantile Apnea and Home Monitoring, 1986
There are actually several terms used for the description of apnea in infants based on the conference statement from the National Institutes of Health on Infantile Apnea and Home Monitoring issued in October of 1986. These definitions, seen in the sidebar article, are becoming recognized worldwide and are used in most research on this subject.

Types of apnea monitors
The standard for home apnea monitoring operates on the principle of transthoracic impedance combined with electrocardiogram (ECG) monitoring. Impedance monitoring is considered an indirect technique for monitoring respiration in contrast to end-tidal carbon dioxide (CO2) and airflow monitoring. Most monitors utilize two standard ECGs placed on the patient’s anterior chest in the midaxillary line. The monitor passes a small, low-amplitude, high-frequency electrical current between the two electrodes and calculates the thoracic impedance.

The impedance of the chest wall will increase with inspiration due to increased gas volume in the thorax and blood volume during the cardiac cycle. The impedance contributed by muscle and fat remains relatively constant. The variation in thoracic impedance is greater during respiration than during the cardiac cycle; therefore, the impedance of the chest will increase with inspiration and decrease during expiration. The voltage between the leads will fluctuate as the chest expands and contracts with respiration. The monitor then uses an algorithm to calculate a respiratory rate based on the changing thoracic impedance and displays the calculated respiratory rate.

The monitor is typically small, portable, and has alarms the clinician can set either high or low for apnea and heart rate. A grounded outlet typically powers the unit, but most units also have a battery backup feature.

Impedance monitoring has inherent shortcomings in accurate respiration detection in cases of body movement and postural changes. In cases of shallow breathing, the monitor may detect the cardiac cycle and count them as respirations, causing a false estimation of displayed respiratory rate. Also, since the monitor bases respiration on changes on thoracic impedance, it cannot detect situations of obstructive apnea. The monitor cannot assess effective ventilation, only changes in impedance; therefore, a respiratory rate may be displayed and no alarm will sound to alert the caregiver.

Placement of the leads is critical. A false alarm may be triggered if the leads are placed too low, near the abdomen, causing interference of the signal. If the leads are placed too high, the monitor may miss the majority of abdominal respiratory effort displayed by many infants and again cause a false alarm to sound. When a caregiver responds to an alarm situation only to find nothing apparently wrong, it is difficult to assess whether the alarm event was real.

The repeated occurrence of false alarms has led to the development of the newer documentation-type monitors. These new monitors not only record

**References**


**Suggested Reading**

the apnea event but basic data prior to and after the event, such as transient heart rate decelerations, bradycardia, apnea, and oxygen desaturation if the monitor is so equipped.

Some of the newer monitors can store data such as ECG waveforms, heart rate trends, respiratory effort waveforms, oxygen saturations, and airflow, strainage, or CO₂ physiologic signals on a computer chip to be downloaded even over a computer modem for interpretation.

Some models can also document the infant’s body position as prone or non-prone. It has been found that these home documentation monitors are very accurate and have distinctive advantages over simple cardiorespiratory monitoring in documenting and identifying life-threatening events.4

**Does apnea monitoring save lives?**

Home apnea monitoring is increasingly prescribed despite a lack of an established standard. There is a lot of controversy in the literature regarding the effectiveness of home apnea monitors. To conduct a truly randomized control study to prove the effectiveness of home apnea monitoring would be highly unethical and potentially libelous. Therefore, the development of standards in identifying the truly at-risk infant would be very helpful.

Currently, there are no published time standards or guidelines in the use of home apnea monitoring, but the AARC “Uniform Reporting Guide for Diagnostic Services” has established a time standard and guidelines for the procedure of infant sleep study, including scoring/analysis. Applying these standards to infants undergoing testing to determine the need for home apnea monitoring should help standardize the screening process, allowing for more concise testing and accurate results.

In a paper published by Crowell et al in the July 1997 issue of the journal *Sleep*, they found reliability of infant polysomnography was maximized with strict detailed scoring guidelines and training.5 With the application of these new standards, the prescription of home apnea monitoring should be able to identify those homebound infants who require home apnea monitoring.

With the increasing use of home documentation monitors, a cost-effective, efficacious tool will be given to clinicians to allow more accurate interpretation of data obtained from the monitor.

With the ability to analyze stored data from a suspected ALTE via modem, hospital personnel can quickly assess whether the event was a true event and direct the parents on what needs to be done to care for the infant. If the event were false, it would give the parents significant relief in anxiety trying to determine if the alarm was valid or not. Also by storing data, the monitor gives the physician detailed information on compliance in use of the monitor and documented events. By having this data to interpret, the physician can then more accurately determine when home apnea monitoring can be safely discontinued.

As more premature infants are being discharged early from the NICU and its associated technology, standardized guidelines for the application and utilization of home apnea monitoring need to be developed. With such guidelines, the truly at-risk homebound infant could be identified and provided with appropriate home monitoring.

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