SIDS, ALTE, Apnea, and the Use of Home Monitors

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Objectives

After completing this article, readers should be able to:

1. Describe the effects of the "Back to Sleep" campaigns on the incidence of sudden infant death syndrome (SIDS).
2. Delineate modifiable risk factors of SIDS.
3. Explain the relationship of apnea and SIDS.
4. Delineate recommendations for the prevention of SIDS.

Introduction

Sudden infant death syndrome (SIDS) has been the focus of extensive research over the past several decades. This review examines the epidemiologic aspects of this syndrome, potential prevention strategies, and the use of home monitoring.

Definitions

Also referred to as crib or cot death, SIDS has been defined by the National Institutes of Health Consensus Development Conference on Infantile Apnea and Home Monitoring as "the sudden death of an infant or young child, which is unexplained by history and in which a thorough postmortem evaluation fails to demonstrate an adequate cause of death." A thorough postmortem evaluation includes a complete autopsy, review of the death scene, and review of the clinical history. The consensus statement defined an apparent life-threatening event (ALTE) as "an episode that is frightening to the observer and is characterized by some combination of apnea, color change, change in muscle tone, choking, or gagging." It is noted in this statement that terminology used previously, such as "aborted crib death" or "near-miss SIDS," should be abandoned because it implies a possibly misleadingly close association between this type of spell and SIDS.

Apnea of infancy is defined as 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. This generally is applied to infants who are older than 37 weeks' gestation. This diagnosis usually is reserved for infants who have ALTE for which a specific cause has not been delineated that is believed to have been related to apnea.

Abbreviations

ALTE:	apparent life-threatening event
CHIME:	Collaborative Home Infant Monitoring Evaluation
GER:	gastroesophageal reflux
IUGR:	intrauterine growth restriction
NICHD:	National Institute of Child Health and Human Development
SIDS:	sudden infant death syndrome

Epidemiology

In the 1999 Annual Summary of Vital Statistics in *Pediatrics*, SIDS was the third leading cause of infant mortality, following congenital anomalies and disorders related to short gestation and unspecified low birthweight. The rate of SIDS was 64.1 per 100,000 live births. This rate represents a significant decline of more than 40% in the United States since 1992, when the American Academy of Pediatrics (AAP) issued the recommendation that infants be placed on their backs or sides to sleep. Similar dramatic decreases in the incidence of SIDS have been demonstrated in other countries after warnings against prone sleeping had been implemented. In the United States, a review of SIDS mortality between 1991 and

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1995 demonstrated that this decline in incidence appears to be shared across all gestational age and birthweight categories and is independent of shifts in population characteristics.

The peak incidence of SIDS is between 3 and 5 months postnatal age, with approximately 90% of cases occurring within the first 6 months of life. For preterm infants, the peak incidence occurs at mean postconceptional ages of 44.2, 46.8, and 52.7 weeks for infants born at 24 to 28, 29 to 32, and 37 weeks' gestation, respectively. Sudden unexpected death beyond the first year of life is not considered to be a result of SIDS.

In the United States, rates of SIDS are higher in the African-American population than in the Caucasian, Hispanic, and Asian populations. A downward trend in the rate of SIDS is occurring in all racial categories, but the African-American population continues to have a significantly higher incidence. Studies investigating the incidence of nonprone sleeping in infants have shown that more infants are placed in this position subsequent to the campaigns, but this trend is lower in African-American infants, which may be contributing to the consistently higher incidence of SIDS in this population.

Pathogenesis/Risk Factors

The underlying etiology of SIDS is not completely understood, despite extensive research over the past 50 years. Evidence suggests a delayed development of arousal, cardiorespiratory, or cardiovascular control in infants who were victims of SIDS, with the speculation that they were unable to arouse sufficiently to a noxious stimulus. Potential theories on noxious stimuli to which infants are exposed include overheating and rebreathing of air, leading to hypercarbia and hypoxia.

Epidemiologic risk factors for SIDS include male gender, low birthweight or prematurity, maternal smoking during pregnancy, seasonal distribution with a peak in winter months, lower socioeconomic status, young maternal age, higher parity, single parenthood, and multiple gestation.

By the beginning of the 1990s, data had emerged that implicated the prone sleeping position as a significant risk factor for SIDS. Many countries, including the United States, embarked on national campaigns warning parents of the association between the prone sleeping position and an increased incidence of SIDS. As noted previously, such campaigns had a significant impact worldwide. The reduced incidence was associated with an overall decrease in infant mortality, suggesting a true reduction in incidence as opposed to diagnostic transfer.

Case-control studies have been conducted in several countries to delineate epidemiologic features of victims of SIDS subsequent to these prevention campaigns. Information reconfirmed prior risk factors for SIDS, including prone sleeping, low birthweight, prematurity, intrauterine growth restriction (IUGR), young maternal age, single motherhood, higher parity, fewer years of education, and lower socioeconomic status. Infants who had the combination of prone sleeping and suboptimal uterine conditions (ie, low birthweight, prematurity, IUGR, or maternal smoking) had a higher risk.

The initial campaigns recommended back or side sleeping as alternatives to prone sleeping. However, subsequent studies have implicated the side sleeping position as a significant risk factor. This appears to be a less stable position, with many infants who were put to bed on their sides subsequently found in different positions. Although the supine position is preferred for infants, those who are placed on their sides to sleep should be positioned with the dependent arm forward to prevent rolling to the prone position. However, evidence suggests that despite positioning with the lower arm forward, there still may be an increased risk to the infant in the side position. Also, infants who were placed primarily in a nonprone position but were placed prone for their last sleep were at significantly high risk. This is of particular concern for those infants whose parents have adhered to the "Back to Sleep" recommendations, then enter child care in which the caregivers place the infants in a prone position.

Many studies have implicated maternal smoking, particularly during pregnancy, as a significant risk factor for SIDS. The studies performed after the "Back to Sleep" campaigns have continued to validate this increased risk to infants. In fact, maternal smoking during and after pregnancy is emerging as the highest modifiable risk factor subsequent to the success of the change in sleep position. A meta-analysis published in 1997 by Anderson and Cook reviewed studies investigating the effect of prenatal and postnatal tobacco exposure and the risk of SIDS. The results showed a significant correlation between postnatal tobacco exposure and SIDS. Although prenatal exposure frequently was confounded by postnatal exposure, making it impossible to determine whether prenatal exposure was an independent risk, both exposures to the infant should be avoided. Unfortunately, this behavior has been very difficult to modify.

Additional risk factors include unsafe sleep conditions and overheating. Unsafe sleep conditions include soft bedding (sofas, waterbeds, sheepskins, and soft mattresses) and potentially obstructive materials in the infant's bed (loose bedding, stuffed toys, pillows, quilts, or

comforters). A recent study by Kemp et al investigated the death scene of infants who died of SIDS, accidental suffocation, and undetermined causes. The majority of the infants had been in unsafe sleep conditions at the time of death. These conditions included soft sleep surfaces, heads covered by bedding, shared surface, or prone with face down or to the side. Only 8.4% of the infants were found alone in a nonprone position without obstruction of the external airway.

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The risk to infants while sharing a bed with the parents has been controversial. Several case-control studies have shown that bed-sharing in conjunction with maternal smoking is a significant risk factor for SIDS. Results of studies of bed-sharing with a nonsmoking parent are inconclusive. There is evidence of an increased risk associated with bed-sharing in combination with parental alcohol or other drug use. When infants are sharing a bed, they are being placed on sleep surfaces that have not been deemed safe by the Consumer Product Safety Commission, which likely is contributing to the potential risk.

Relationship Between Apnea and SIDS

In 1988, results were published of the National Institute of Child Health and Human Development (NICHD) SIDS cooperative epidemiological study. This case-control study assessed risk factors of SIDS in the United States. The study included 757 "definite or probable" SIDS infants and 1,514 controls. The investigators found no association attributable to apnea in the nursery and SIDS. In addition, when victims of SIDS were compared with controls matched for race and birthweight, there was no significant increase in the incidence of preterm SIDS cases compared with preterm control infants. The study concluded that newborn apnea or apnea of prematurity is not a risk factor for SIDS. Mothers of infants who suffered SIDS reported an apneic event (ALTE) more frequently than controls beyond the newborn period. However, this constituted only a small proportion of the SIDS cases. In addition, documentation of such events was by parental report alone; there was no objective verification of such events, which raises the possibility of recall bias. A role for postneonatal apnea in SIDS could not be established. In addition, studies reviewing documented monitoring in infants who died suddenly and unexpectedly at home revealed the occurrence of prolonged bradycardia before any prolonged central apnea.

Recurrence Risk in Siblings

Much controversy surrounds the risk of SIDS in infants who had a sibling die of sudden unexpected death. Results of multiple studies are inconclusive. Determining recurrence risk in a sibling of an infant who has died of SIDS is problematic because SIDS is a relatively infrequent event; therefore, subsequent events in a sibling are extremely rare. Much of the data reported in these studies was obtained in a period when autopsy evaluation and death scene investigation were not routine, which potentially affects the accuracy of the SIDS diagnosis. In earlier studies, autopsies were obtained in as few as 50% of victims. Many studies of epidemiologic risk failed to exclude nonaccidental trauma as a possible diagnosis, particularly in cases of multiple deaths in a single family. In addition, many of the studies investigating sibling risk were performed prior to this last decade, when the change in sleep position made a substantial impact on the incidence of SIDS. It is likely that recurrence risk in these studies was confounded by continued unsafe practices by the parents.

Infanticide

Although the vast majority of cases of sudden infant death are idiopathic or the result of accidental suffocation, the possibility of intentional suffocation by a caretaker cannot be overlooked. Covert video recordings have documented caregivers inflicting intentional harm on children who have a history of recurrent ALTEs.

Intentional suffocation is difficult to diagnosis via autopsy examination of an infant. For this reason, it is difficult to separate infants dying of SIDS from infants who are victims of intentional suffocation or infanticide. In investigating the risk of SIDS to subsequent siblings, it can be very difficult to control for this alternative diagnosis. Accordingly, studies may be confounded by the

inclusion of nonaccidental trauma among cases diagnosed as SIDS.

It has been estimated that the incidence of infanticide in cases designated as SIDS ranges from less than 1% to 5%. The AAP Committee on Child Abuse and Neglect recently submitted guidelines for distinguishing SIDS from child abuse fatalities, citing certain circumstances that should alert the clinician to the possibility of child abuse. These include: previous recurrent cyanosis, apnea, or ALTE while in the care of the same person; age at death older than 6 months; previous unexpected or unexplained deaths of one or more siblings; simultaneous or nearly simultaneous deaths of twins; previous death of infants under the care of the same unrelated person; or discovery of blood on the infant's nose or mouth in association with ALTE. The investigation of infants dying suddenly and unexpectedly must be thorough and include a postmortem examination with radiographic skeletal survey, toxicologic and metabolic screening, a prompt death scene investigation, accurate history obtained by emergency responders and medical personnel, collection of medical history, and locally based infant death review teams to review collected data with participation of the medical examiner or coroner.

ALTE

As defined previously, an ALTE is an episode in which the infant has clinical symptoms that are frightening to the observer, in some cases to the degree that the observer fears the infant has died. As might be expected, these episodes generate substantial anxiety, not only in the parents of the child, but also in the caregiver evaluating whether the episode truly was life-threatening and deciding how to proceed.

The evaluation begins with a thorough history and physical examination. One of the biggest challenges is determining the severity of the event. Very detailed questioning about the event should ensue, ideally from the person who witnessed it. Questions should include the duration of the episode; intervention required for the episode to cease; color changes in the infant (and lighting in the room to clarify the ability to observe the infant's color); respiratory effort; muscle tone; activity of the infant immediately prior to the event; relationship to time of feeding; and the presence of choking, gasping, emesis, rhythmic movements, eye movement, nasal congestion, or fever. It also should be clarified if the infant appeared normal after the event and the length of time for him or her to reach that stage. In addition to the history of the event, the medical history should be evaluated thoroughly, including pregnancy, birth, neonatal period, subsequent medical problems, and a complete review of systems. Details of the family history should be ascertained, with particular attention to genetic or neurologic disorders, cardiac disease, infants dying suddenly and unexpectedly, and prior ALTEs in other family members. A detailed physical examination should focus specifically on neurologic, respiratory, or cardiac abnormalities.

The differential diagnosis for such events can be broad. It includes infection (particularly pertussis, respiratory syncytial virus, sepsis, or meningitis), gastroesophageal reflux (GER), seizures or other neurologic disorders, airway anomalies, aspiration, asthma, cardiac dysrhythmias such as prolonged QT syndrome, metabolic abnormalities, apnea of infancy, and nonaccidental trauma or Munchausen by proxy. The etiology in as many as 50% of ALTEs remains idiopathic. In some instances, the event is the result of benign perfusion changes in the infant that lead to overreaction by the caregiver. Details of the history and physical examination are critical in guiding subsequent evaluation of the events. One of the most important aspects is to determine the true severity of the event and proceed with the evaluation according to details of the event. A nonfocused evaluation ruling out all potential diagnoses is costly and unwarranted.

Most infants who experience an ALTE should be hospitalized for further evaluation. However, in cases in which the child appears completely normal and the details of the event indicate a benign occurrence, it may be appropriate to follow the infant as an outpatient. If the episode appears to be significant or required vigorous resuscitation or results of the physical examination are abnormal, further evaluation is warranted. These infants should be placed on continuous monitoring, and detailed descriptions of subsequent events should be documented. The initial evaluation may include a complete blood count with differential count to evaluate for evidence of infection or anemia and assessment of serum electrolytes and glucose for metabolic abnormalities. As noted previously, further evaluation is based primarily on details obtained through the history and physical examination that may suggest possible etiologies. Additional studies may include cardiac evaluation, including electrocardiography or echocardiography; neurologic testing, including electroenchephalography or cranial computed tomography; and esophageal pH probe or upper gastrointestinal contrast study to evaluate for GER.

Care must be taken when evaluating an infant who is believed to be the victim of nonaccidental trauma or Munchausen by proxy. In these instances, covert video

surveillance may provide documentation of the inflicted events. Multichannel pneumograms may help to clarify the details of the event and guide therapy. However, these studies are ineffective for screening to identify infants at risk for SIDS. They have not been shown to be predictive in identifying the occurrence or severity of subsequent events, including both apnea of infancy and sudden death and, therefore, do not provide information about subsequent risk.

Treatment of infants who have suffered ALTEs should be focused toward results of the evaluation. Infants who have had seizures should receive appropriate anticonvulsants. Chalasia precautions, including thickened feedings or medications such as metoclopramide and ranitidine, may benefit some infants who have GER. Infants who have infections require appropriate antibiotics and supportive care.

Home Monitoring

Home monitoring is used widely in an attempt to prevent SIDS among infants at risk. Although no randomized controlled studies have assessed the effectiveness of this intervention, some clinicians believe that the use of monitors will protect infants. Uncontrolled studies have not been able to show that their use is effective in preventing SIDS. Epidemiologically, no change in the incidence of SIDS has been correlated with the use of home monitors, despite their almost routine use for the past 25 years.

Several assumptions inherent in home monitor use never have been proven by any scientific study. First, there is no evidence that infants for whom home monitors are recommended are at increased risk for episodes of prolonged apnea or bradycardia. Second, there is no evidence that such episodes are precursors of SIDS. Finally, there is no evidence that home monitoring will warn caregivers in time to intervene or that any intervention will prevent unexpected death.

The theory that apnea is the pathophysiologic precursor to SIDS initially was espoused by Steinschneider in 1972, but it never has been proven, despite extensive independent research. Steinschneider documented apnea in two siblings by monitoring them during prolonged hospitalization, and both subsequently died unexpectedly at home under the care of their mother. Three additional siblings had died previously and unexpectedly at home. More than 2 decades later, the mother confessed and was found guilty of murdering all five children. Nonetheless, this report of multiple familial deaths was publicized throughout the lay and scientific communities in the 1970s and 1980s as validation of the apnea/SIDS theory and was the foundation for propagation of home monitoring throughout this country as the standard of care (and, therefore, as an industry) for management of infants at risk of unexpected death from SIDS for the past 25 years. This history is chronicled by Firstman and Talan (see Suggested Reading).

In addition, no studies have shown that SIDS and idiopathic ALTEs are the result of the same mechanism and that an ALTE would result in death. Fewer than 10% of SIDS victims have a history of a prior ALTE.

In the United States, the Collaborative Home Infant Monitoring Evaluation (CHIME) was a multicenter study designed to assess several of the unanswered questions regarding home monitoring. The study, supported by the NICHD, had specific aims, which included: 1) assessment and comparison of the incidence of clinically important events identified by documented monitoring in infants considered to be at risk for SIDS (including apnea of infancy patients, siblings of SIDS, preterm infants ≤1,750 g at birth) and in normal infants; 2) seeking of antecedent predictors of clinically significant events; 3) determination of the outcome of such events; and 4) assessment of the extent of family compliance achievable with state-of-the-art documented monitoring. The findings of this study of 1,079 infants and 718,000 hours of monitoring demonstrated that both conventional apnea and bradycardia and extreme apnea and bradycardia are relatively common events, even among healthy term infants. The only group that had an increased risk of such events compared with healthy term infants was preterm infants, and only up to 43 weeks' postconceptional age. It is of note that the peak incidence of SIDS is more than 43 weeks' postconceptional age for preterm infants of any gestational age. Therefore, the evidence suggests that prolonged apnea and bradycardia are not immediate precursors of SIDS. The CHIME study could not determine if infants who had episodes of extreme apnea or bradycardia were at higher risk for SIDS, if home monitoring could provide warning in time for intervention, or if intervention would prevent unexpected death. Nonetheless, other epidemiologic studies have failed to document any impact of home monitoring on the incidence of SIDS.

Given the lack of evidence that home monitoring has any impact on SIDS, prevention of SIDS should not be an indication for home monitoring. Home monitoring may be used to document apnea, bradycardia, or hypoxemia (depending on the monitor used), but there is no evidence that any of these events is associated with an increased risk of SIDS. In fact, the overwhelming evidence suggests that they are not. There is no evidence

that monitoring will decrease the risk of SIDS in preterm infants who do or do not have apnea, siblings of SIDS victims, or infants who have had a prior ALTE. In fact, the evidence that siblings of SIDS victims or infants who have had an ALTE are at any increased risk for SIDS is inconclusive and inadequate. In other words, there is no good evidence that either of these groups is at increased risk of SIDS.

Home monitoring may be considered in the preterm infant who is at high risk for recurrent apnea of prematurity after discharge to recognize such episodes at home. This generally includes infants who continue to have documented apnea, bradycardia, and cyanosis when all other criteria for discharge have been met. If such episodes are associated with hypoxemia and the goal is to intervene to minimize such hypoxemic events, monitoring may be justified (although no studies have correlated long-term outcome with such events or with monitoring of such events). However, monitoring should be undertaken generally only until approximately 43 weeks' postconceptional age. Similarly, infants who have had documented ALTEs may warrant monitoring if it is intended to recognize an episode of apnea, bradycardia, or desaturation. Parents need to be informed about the purpose of the monitoring and what it can and cannot do. Monitoring of infants who are technology-dependent (eg, tracheostomy, home continuous positive airway pressure) or who have other rare medical conditions affecting regulation of breathing may be warranted.

Management

The primary focus for SIDS should remain on prevention. In light of the success of "Back to Sleep" campaigns worldwide, public health campaigns should be continued. They should be broadened to include other modifiable risk factors, such as smoking and unsafe sleep practices. Whether there are protective factors for SIDS remains controversial. Some evidence suggests that breastfeeding may be protective, but this has not been substantiated. The use of pacifiers also may be protective, although controversy surrounds the use of pacifiers in breastfeeding infants. The AAP has not made specific recommendations about the use of pacifiers in relation to the prevention of SIDS.

Prognosis

Prevention campaigns through the past decade have been successful in decreasing the incidence of SIDS internationally. Although it is unlikely that this disorder will be eliminated completely, the incidence may be decreased further through continued education of the lay and scientific communities. Appropriate and limited use of home monitors should be a part of this ongoing educational campaign.

Suggested Reading

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PIR Quiz

Quiz also available online at *www.pedsinreview.org.*

1. Which of the following has been shown to be associated with an increased risk of SIDS?

   A. Anemia.
   B. Infant born postterm.
   C. Maternal smoking.
   D. Recent immunization.
   E. Supine sleeping position.

2. Which of the following statements regarding SIDS is *true*?

   A. Infants who have apnea of prematurity have an increased risk of SIDS.
   B. Most infants who die from SIDS have a history of a previous ALTE.
   C. Siblings of infants who died of SIDS have been proven to be at significant risk for SIDS.
   D. Soft sleep surfaces increase the risk of SIDS.
   E. The "Back to Sleep" campaign has had no effect on the incidence of SIDS.

3. Which of the following is the *best* indication for prescribing home monitoring for a patient?

   A. A family history of SIDS.
   B. An ALTE lasting a few seconds without apnea.
   C. Documented apnea with cyanosis in the hospital.
   D. Parental anxiety.
   E. Seizure disorder.

4. You are evaluating a 1-month-old infant in the emergency department. His mother reports that he stopped breathing for 5 to 10 seconds. She also noted perioral cyanosis and formula coming from his mouth. This episode occurred about 10 minutes after a feeding; after two rescue breaths, he began to breathe again. She is very concerned about the possibility of SIDS. The infant is afebrile and pink. He is alert and feeding vigorously, and results of the physical examination are within normal limits. Which of the following is the *most* appropriate course of action?

   A. Admit him to the hospital and perform an extensive evaluation, including electrocardiography, echocardiography, and lumbar puncture.
   B. Admit him to the hospital overnight for observation and perform a barium swallow.
   C. Arrange for outpatient multichannel pneumography.
   D. Prescribe a home apnea monitor for him immediately.
   E. Reassure the mother and discharge the infant home.