Suffocation and Sudden Infant Death Syndrome (SIDS): A Selected Annotated Bibliography

Takatsu A, Shigeta A, Sakai K, Abe S.
**Risk factors, diagnosis and prevention of sudden unexpected infant death.**

The diagnosis of the cause of sudden unexpected infant death (SUID) is often difficult work for forensic pathologists. Its misdiagnosis or misclassification is the cause of crucial epidemiological and medicolegal problems. During the sudden infant death syndrome (SIDS) epidemic, many reports described the risk factors of SIDS as well as mechanical suffocation during sleep. Meadow's report has invited worldwide debate over whether the cause of SUID is attributable to SIDS or suffocation. On the basis of this background, the problems concerning causal diagnosis and risk factors, particularly the accidental suffocation of infants during sleep, and the specific pattern of suffocation, was reviewed from the forensic pathological viewpoint. The following tasks remain to be done for the future: (1) to avoid preventable SUIDs, the most effective measure worldwide is to identify high-risk factors for all SUIDs, including SIDS, accidental suffocation and undetermined causes, and then transmit this information to the public. (2) SIDS should be uniformly defined and diagnosed as strictly as possible to gain its reliability in the public health community and in a legal framework.


Krous HF, Chadwick AE, Haas EA, Stanley C.
**Pulmonary intra-alveolar hemorrhage in SIDS and suffocation.**
J Clin Forensic Med. 2007 Jan 23; [E-pub ahead of print]

The differentiation of SIDS from accidental or inflicted suffocation may be impossible in some cases. Severe pulmonary intra-alveolar hemorrhage has been suggested as a potential marker for such differentiation. Our aims are to: (1) Compare pulmonary hemorrhage in SIDS and a control group comprised of infants whose deaths were attributed to accidental or inflicted suffocation. (2) Review individual cases with the most severe pulmonary hemorrhage regardless of the cause of death, and (3) Assess the effect of age, bedsharing, cardiopulmonary resuscitation, and postmortem interval, with regard to the severity of pulmonary hemorrhage in SIDS cases. We conducted a retrospective study of all postneonatal cases accessioned by the Office of the Medical Examiner in San Diego County, California who died of SIDS or suffocation between 1999 and 2004. A total of 444 cases of sudden infant death caused by SIDS (405), accidental suffocation (36), and inflicted suffocation (3) from the San Diego SIDS/SUDC Research Project database were compared using a semi quantitative measure of pulmonary intra-alveolar hemorrhage [absent (0) to severe (4)]. Grades 3 or 4 pulmonary hemorrhage occurred in
33% of deaths attributed to suffocation, but in only 11% of the SIDS cases, however, all grades of pulmonary hemorrhage occurred in both groups. Therefore, our results indicate that the severity of pulmonary hemorrhage cannot be used in isolation to determine the cause or manner of sudden infant death. Among SIDS cases, those with a higher pulmonary hemorrhage grade (3 or 4) were more likely to bed share, and with more than one co-sleeper, than those with a lower pulmonary hemorrhage grade (0 or 1). We conclude that each case must be evaluated on its own merits after thorough review of the medical history, circumstances of death, and postmortem findings.


Krous HF, Haas EA, Masoumi H, Chadwick AE, Stanley C.
A comparison of pulmonary intra-alveolar hemorrhage in cases of sudden infant death due to SIDS in a safe sleep environment or to suffocation.
Forensic Sci Int. 2007 Jan 11; [E-pub ahead of print]

The differentiation of SIDS from accidental or inflicted suffocation may be impossible without corroborating findings from the death scene or autopsy or in the absence of a confession from a perpetrator. Pulmonary intra-alveolar hemorrhage (PH) has been proposed as a potential clue to suffocation, but none of the previous studies on this topic have limited SIDS cases to those who were in a safe sleep environment, in which all were found supine and alone on a firm surface with their heads uncovered. Our aims are to: (1) compare PH in SIDS cases found in a safe sleep environment to a control group comprised of infants whose deaths were attributed to accidental or inflicted suffocation and (2) assess the effect of age, CPR, and postmortem interval (PMI), with regard to the severity of PH in this subset of safe-sleeping SIDS cases. We conducted a retrospective study of all post neonatal cases accessioned by the Office of the Medical Examiner in San Diego County, California who died of SIDS or suffocation between 1999 and 2004. A total of 74 cases of sudden infant death caused by SIDS (34 cases as defined above, comprising 8% of the total SIDS cases), accidental suffocation (37), and inflicted suffocation (3) from the San Diego SIDS/SUDC Research Project database were compared using a semi quantitative measure of pulmonary intra-alveolar hemorrhage. The most severe (grade 3 or 4) PH occurred in 35% of deaths attributed to suffocation, but in only 9% of the SIDS cases. Age, duration of CPR attempts and PMI had no effect on the severity of PH in SIDS. Our results indicate that the severity of PH cannot be used independently to differentiate SIDS from suffocation deaths. Each case must be evaluated on its own merits after thorough review of the medical history, circumstances of death, and postmortem findings.


Byard RW, Blumbergs P, Scott G, Kennedy JD, Riches KJ, Martin J, Thompson GN.
The role of beta-amyloid precursor protein (beta-APP) staining in the neuropathologic evaluation of sudden infant death and in the initiation of clinical investigations of subsequent siblings.
This report highlights the importance of undertaking immunohistochemical staining of the brains of infants who die unexpectedly, as it may not only assist with the evaluation of the cause of death in an individual infant but may also help with the clinical management of subsequent siblings. A 5-month-old male infant who died suddenly was found to have diffuse beta-amyloid precursor protein (beta-APP) staining in the brain, with no unusual features in his history, death scene examination, routine autopsy dissection, and ancillary tests to suggest any definite cause of death. Due to the beta-APP staining, the possibility of previous episodes of occult trauma, apparent life threatening events (ALTEs), and accidental or inflicted suffocation was raised in the autopsy report. As detailed analyses and investigations provided no supportive evidence for trauma or inflicted injury, hypoxia was clinically considered the most likely cause. Because of these concerns, sleeping oxygen saturation levels were monitored following the birth of a subsequent sibling who had normal APGAR scores and no evidence of any health problems. Oxygen desaturation to 70% occurred in association with a color change while on the postnatal ward, and a subsequent polysomnogram showed multiple episodic significant desaturations to around 80% in association with central apnea. Other testing was unremarkable. These cases demonstrate that beta-APP staining of the brain may not only provide clues as to possible mechanisms of death in pediatric forensic cases but may indicate a need for careful clinical evaluation of subsequent siblings for possible central apnea requiring oxygen therapy.

Full-text available at: http://www.amjforensicmedicine.com (not a U.S. Government site)


There is currently no accepted explanation in the medical literature for the lower female total mortality rate in infancy, childhood and adulthood. We review the pediatric mortality data provided by Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) and show that for causes of respiratory infant death that are apparently independent of gender (e.g., suffocation from inhalation of food or other object), there is a consistently one-third lower rate of mortality in the female than in the male. This one-third lower mortality for causes of death with a respiratory terminal event is hypothesized to be due to an X-linked dominant allele that occurs with frequency 1/3. It appears as if a second X chromosome provides the one-third extra probability of protection afforded for an XX female compared with an XY male. It is suggested that the allele's function is unmasked during transient periods of cerebral anoxia, requiring a mechanism for anaerobic oxidation to prevent the death of respiratory control neurons in the brain stem. Examples of the female one-third extra chance of resistance to hypoxia are given for causes of death in infancy, such as infant respiratory distress syndrome (IRDS) and sudden infant death syndrome (SIDS), and for causes of suffocation in childhood and asphyxiation in adulthood. DNA testing of the X chromosome of probands from causes of respiratory death, such as SIDS and IRDS, where there is a one-third
lower female than male death rate, is a future direction that can verify the existence of the proposed allele.

American Academy of Pediatrics; Hymel KP; Committee on Child Abuse and Neglect; National Association of Medical Examiners.

**Distinguishing sudden infant death syndrome from child abuse fatalities.**

Fatal child abuse has been mistaken for sudden infant death syndrome. When a healthy infant younger than 1 year dies suddenly and unexpectedly, the cause of death may be certified as sudden infant death syndrome. Sudden infant death syndrome is more common than infanticide. Parents of sudden infant death syndrome victims typically are anxious to provide unlimited information to professionals involved in death investigation or research. They also want and deserve to be approached in a nonaccusatory manner. This clinical report provides professionals with information and suggestions for procedures to help avoid stigmatizing families of sudden infant death syndrome victims while allowing accumulation of appropriate evidence in potential cases of infanticide. This clinical report addresses deficiencies and updates recommendations in the 2001 American Academy of Pediatrics policy statement of the same name.

Full-text available at: http://www.pediatrics.org (not a U.S. Government site)

Krous HF, Wixom C, Chadwick AE, Haas EA, Silva PD, Stanley C.

**Pulmonary intra-alveolar siderophages in SIDS and suffocation: A San Diego SIDS/SUDC Research Project report.**

Pulmonary intra-alveolar siderophages (PS) have been suggested as a marker of previous attempts at imposed suffocation in infants dying suddenly and unexpectedly. The aims of this study were to (1) compare PS counts between cases of sudden infant death syndrome (SIDS) and a control group comprised of infants whose deaths were attributed to accidental or inflicted suffocation, (2) compare clinical variables in SIDS and control suffocation cases, and (3) review individual cases irrespective of the cause and manner of death with an average PS count greater than 200 per 20 high-power fields (hpf) per lung lobe. Retrospective assessment of siderophages in available iron-stained lung sections was undertaken in 91 SIDS cases and 29 cases of death due to suffocation (27 accidents and 2 homicides) from the San Diego SIDS and Sudden Unexplained Death in Childhood (SUDC) Research Project (SDSSRP) database. Neither the means of the log-transformed PS counts nor the medians of the raw PS counts were significantly different between the SIDS and control suffocation groups. The distributions of the PS data were different, however-the range was wider in the SIDS group. Only 6% of each group had a history of prior apparent life-threatening events. Approximately three fourths of the families from both groups had no prior referral to Child Protective Services. The number of PS varies widely in cases of sudden infant death caused by SIDS and accidental or inflicted suffocation
suffocation and cannot be used as an independent variable to ascertain past attempts at suffocation.

Full-text available at: http://springerlink.metapress.com (not a U.S. Government site)

Perrizo K, Pustilnik S.  

Our retrospective case review from 1978-2002, of infant deaths autopsied under the auspices of the Galveston County Medical Examiner Office, demonstrated a lack of detailed scene investigation, including sleeping circumstances and arrangements, as well as a pattern of ascribing the cause of death to SIDS even when there is evidence of a hazardous sleeping arrangement. During this period, 89/103 pediatric deaths were certified as SIDS and 39/103 of these were co-sleeping, 51/103 were sleeping alone, and 17/103 had no sleeping arrangement indicated. Upon review, there were only 6 cases where the scene visitation was documented. Only 9 cases used an Infant Death Investigation Form (IDIF), and this only started in 1999. The IDIF contains questions regarding the infants' sleep environment (bedding descriptions, co-sleeping, sleep surface) not used in the standard medical examiner death investigative forms. There has been an upward trend since the late 1990s in the number of scenes visited and detailed descriptions of the scenes, likely due to the increased awareness of hazardous infant sleeping conditions identified by American Academy of Pediatrics and U.S. Consumer Product Safety Commission. The association between co-sleeping and sudden infant death remains controversial among clinicians. We report a high association between these two conditions.

Full-text available at: http://www.amjforensicmedicine.com (not a U.S. Government site)

Shapiro-Mendoza CK, Tomashek KM, Anderson RN, Wingo J.  
Recent national trends in sudden, unexpected infant deaths: more evidence supporting a change in classification or reporting.  

The recent US decline in sudden infant death syndrome (SIDS) rates may be explained by a shift in how these deaths are classified or reported. To examine this hypothesis, the authors compared cause-specific mortality rates for SIDS, other sudden, unexpected infant deaths, and cause unknown/unspecified, and they evaluated trends in the age and month of death for these causes using 1989-2001 US linked birth/death certificate data. Reported deaths in state and national data were compared to assess underreporting or overreporting. SIDS rates declined significantly from 1989-1991 to 1995-1998, while deaths reported as cause unknown/unspecified and other sudden, unexpected infant
deaths, such as accidental suffocation and strangulation in bed (ASSB), remained stable. From 1999-2001, the decline in SIDS rates was offset by increasing rates of cause unknown/unspecified and ASSB. Changes in the cause-specific age at death and month of death distributions suggest that cases once reported as SIDS are now being reported as ASSB and cause unknown/unspecified. Most of the decline in SIDS rates since 1999 is likely due to increased reporting of cause unknown/unspecified and ASSB. Standardizing data collection at death scenes and improving the reporting of cause of death on death certificates should improve national vital records data and enhance prevention efforts.

Full-text available at: http://www.amjforensicmedicine.com (not a U.S. Government site)

Glasgow JF, Thompson AJ, Ingram PJ.
Sudden unexpected death in infancy: Place and time of death.

In recent years, many babies who die of Sudden Unexpected Death in Infancy (SUDI) in Northern Ireland are found dead in bed--i.e. co-sleeping--with an adult. In order to assess its frequency autopsy reports between April 1996 and August 2001 were reviewed and linked to temporal factors. The day and month of death, and the place where the baby was found were compared to a reference population of infant deaths between one week of age and the second birthday. Although the rate of SUDI was lower than the UK average, 43 cases of SUDI were identified, and two additional deaths with virtually identical autopsy findings that were attributed to asphyxia caused by suffocation due to overlaying. Thirty-two of the 45 (71%) were less than four months of age. In 30 of the 45 cases (67%) the history stated that the baby was bed sharing with others; 19 died sleeping in an adult bed, and 11 on a sofa or armchair. In 16 of the 30 (53%) there were at least two other people sharing the sleeping surface, and in one case, three. SUDI was twice as frequent at weekends (found dead Saturday-Monday mornings) compared to weekdays (p<0.02), and significantly more common compared to reference deaths (p<0.002). Co-sleeping deaths were also more frequent at weekends. Almost half of all SUDI (49%) occurred in the summer months--more than twice the frequency of reference deaths. While sharing a place of sleep per se may not increase the risk of death, our findings may be linked to factors such as habitual smoking, consumption of alcohol or illicit drugs as reported in case-control studies. In advising parents on safer childcare practices, health professionals must be knowledgeable of current research and when, for example, giving advice on co-sleeping this needs to be person-specific cognisant of the risks within a household. New and better means of targeting such information needs to be researched if those with higher risk life-styles are to be positively influenced.

Full-text available at: http://www.ums.ac.uk (not a U.S. Government site)

Pollack HA.
Changes in the timing of SIDS deaths in 1989 and 1999: indirect evidence of low homicide prevalence among reported cases.
An unknown proportion of cases diagnosed as sudden infant death syndrome (SIDS) are misdiagnosed, and in some cases are homicides. Because recent SIDS prevention measures were unlikely to reduce homicides, changes in the reported timing of SIDS cases provide an indirect measure of covert homicides in this group. This paper uses United States vital statistics microdata to explore these questions. The sample includes all reported infant deaths to singletons with birthweight > 500 g in the 1989 and 1999 US birth cohorts. Deaths attributed to SIDS (n = 7708), homicide (n = 597), or object inhalation and mechanical suffocation (n = 860) are specifically examined. If reported SIDS cases were a mixture of 'true' cases and misdiagnosed homicides, it is hypothesised that the age-at-death distribution of SIDS deaths would have changed to reflect greater prevalence of misdiagnosed homicide. We find that the age-at-death distribution of reported SIDS cases was virtually unchanged in the two cohorts, showing no increase during periods of infancy when relative homicide risk is most pronounced. One cannot reject the hypothesis that the timing was drawn from the same distribution (chi2(52) = 62.2, P = 0.157). Analogous results hold for infants born in circumstances associated with high homicide risk (chi2(50) = 61.5, P = 0.12). The stable age-at-death distribution of reported SIDS cases between 1989 and 1999 suggests that covert homicides are a small fraction of reported SIDS cases.


Kanawaku Y, Funayama M, Sakai J, Nata M, Kanetake J.

**Sudden infant death: lingual thyroglossal duct cyst versus environmental factors.**


An 8-month-old female baby was found collapsed in the prone position 30 min after being positioned under soft-bedding. She was taken to the emergency room with cardiopulmonary arrest. Her heartbeat was recovered after resuscitation and continued for 20 h under artificial respiration, at which point the child died. At autopsy, the child showed no significant pathological abnormalities apart from a thyroglossal duct cyst of 2.0 cm diameter, therefore, it seemed that the cyst, which was close to the epiglottis, had caused asphyxia through airways occlusion. However, the child had shown no respiratory problems before death, and the risk of airway occlusion as a result of lingual cysts is more likely in a supine rather than a prone position. A small amount of evidence suggested that the child died as a result of suffocation from being covered by soft bedding, which could have caused fatal asphyxia; it is also possible that a hypoxic state induced by airway obstruction might have been enhanced by being covered with bedding. It seemed reasonable to assume that death was caused by a combination of the lingual thyroglossal duct cysts and asphyxia caused by being covered in bedding, though the main factor appeared to be the large cyst.


Landi K, Gutierrez C, Sampson B, Harruff R, Rubio I, Balbela B, Greco MA.

**Investigation of the sudden death of infants: A multicenter analysis.**

3/29/07
The investigation of sudden death of infants varies, and death rates may depend on local practices of death certification. We studied the extent of the investigation and the final cause of death (COD) in 3 regions: New York, New York, USA (NY); King County, Washington, USA (KC); and Montevideo, Uruguay (MU). We conducted a retrospective review of 543 cases (NY 258, KC 56, MU 229) of previously healthy babies who died suddenly without obvious trauma, at ages 0 to 12 months, over a 3-year period (1998 to 2001). All cases included a complete autopsy and histologic examination. Cases were assessed for completion of special studies (including radiographs, photos, toxicology and metabolic sampling, cultures, and vitreous humor chemistry), measurements, and scene investigation. Specialized pediatric measurements and testing were done less often than routine procedures, and were done less often in cases overall compared with cases certified as sudden infant death syndrome (SIDS). Fifty-five percent of SIDS cases in investigation. Manhattan had a complete workup in 42% of SIDS cases, whereas the remaining sites had fewer that 15% of cases completely worked up. The most common non-natural COD was suffocation at all 3 sites. The overall most common COD were respiratory infection in MU (22%) and SIDS in NY (45%) and KC (86%). We conclude that the sudden death of infants requires special consideration and still lacks consistency. SIDS investigations are not done completely in all cases and rates may depend on regional differences in certifying infant deaths.

Full-text available at: http://www.springerlink.com (not a U.S. Government site)

Lahr MB, Rosenberg KD, Lapidus JA.

**Bedsharing and maternal smoking in a population-based survey of new mothers.**


Objective: Sudden infant death syndrome (SIDS) remains the number 1 cause of postneonatal infant death. Prone infant sleep position and maternal smoking have been established as risk factors for SIDS mortality. Some studies have found that bedsharing is associated with SIDS, but, to date, there is only strong evidence for a risk among infants of smoking mothers and some evidence of a risk among young infants of nonsmoking mothers. Despite the lack of convincing scientific evidence, bedsharing with nonsmoking mothers remains controversial. In some states, nonsmoking mothers are currently being told that they should not bedshare with their infants, and mothers of infants who died of SIDS are told that they caused the death of their infant because they bedshared. The objective of this study was to explore the relationship between maternal smoking and bedsharing among Oregon mothers to explore whether smoking mothers, in contrast to nonsmoking mothers, are getting the message that they should not bedshare. Methods: Oregon Pregnancy Risk Assessment Monitoring System surveys a stratified random sample, drawn from birth certificates, of women after a live birth. Hispanic and non-Hispanic black, non-Hispanic Asian/Pacific Islander and non-Hispanic American Indian/Alaskan Native women, and non-Hispanic white women with low birth weight infants are oversampled to ensure sufficient numbers for stratified analysis. The sample then was weighted to reflect Oregon's population. In 1998-1999, 1867 women completed
the survey (73.5% weighted response). The median time from birth to completion of the survey was 4 months. Women were asked whether they shared a bed with their infant "always," "almost always," "sometimes," or "never." Frequent bedsharing was defined as "always" or "almost always"; infrequent was defined as "sometimes" or "never." Results: Of all new mothers, 35.2% reported bedsharing frequently (always: 20.5%; almost always: 14.7%) and 64.8% infrequently (sometimes: 41.4%; never: 23.4%). Bedsharing among postpartum smoking mothers was 18.8% always, 12.6% almost always, 45.1% sometimes, and 23.6% never; this was not statistically different from among nonsmoking mothers. Results for prenatal smokers were similar. When stratified by race/ethnicity, there was no association between smoking and bedsharing in any racial or ethnic group. In univariable and multivariable logistic regression, there were no statistical differences in frequent or any bedsharing among either prenatal or postpartum smoking mothers compared with nonsmokers; the adjusted odds ratio for postpartum smokers who frequently bedshared was 0.73 (95% confidence interval [CI]: 0.42-1.25) and for any bedsharing was 1.05 (95% CI: 0.57-1.94). Results for prenatal smoking were similar. This is the first US population-based study to look at the prevalence of bedsharing among smoking and nonsmoking mothers. Bedsharing is common in Oregon, with 35.2% of mothers in Oregon reporting frequently bedsharing and an additional 41.4% sometimes bedsharing. There was no significant association between smoking and bedsharing for either prenatal or postpartum smokers among any racial or ethnic group. Smoking mothers were as likely to bedshare as nonsmoking mothers. The frequency of bedsharing in Oregon was similar to estimates from other sources. Our study has the advantage of being a population-based sample drawn from birth certificates, weighted for nonresponse. Conclusions: Although a number of case series have raised concerns about the safety of mother-infant bedsharing, even among nonsmoking mothers, this has not yet been confirmed by careful, controlled studies. There have been 9 large-scale case-control studies of the relationship between bedsharing and SIDS. Three case-control studies did not stratify by maternal smoking status, but found no increased risk for SIDS. Six case control studies reported results stratified by maternal smoking status: 1 study, while asserting an association, provided an unexplained range of univariable odds ratios without CIs; 3 found no increased risk for older infants of nonsmoking mothers; and 2 found a risk only for infants <8-11 weeks of age. Despite the preponderance of evidence that bedsharing by nonsmoking mothers does not increase the risk for SIDS among older infants, the recent specter of bedsharing as a cause of SIDS, based on uncontrolled case series and medical examiners' anecdotal experience, has led some medical examiners to label a death "suffocation" or "overlay asphyxiation" simply because the infant was bedsharing at the time of death. This "diagnostic drift" may greatly complicate future studies of the relationship between bedsharing and SIDS. Epidemiologic evidence shows that there is little or no increased risk for SIDS among infants of nonsmoking mothers but increased risk among infants of smoking mothers and younger infants of nonsmoking mothers. It seems prudent to discourage bedsharing among all infants <3 months old. Young infants brought to bed to be breastfed should be returned to a crib when finished. It would be worthwhile for other researchers to reanalyze their previous data to evaluate the consistency of the interaction of young infant age and bedsharing. Large controlled studies that include infants who are identified as dying from SIDS, asphyxia, suffocation, and sudden unexplained infant death, analyzed separately and in combination, are needed.
to resolve this and other issues involving bedsharing, including the problem of diagnostic drift. Recommendations must be based on solid scientific evidence, which, to date, does not support the rejection of all bedsharing between nonsmoking mothers and their infants. Cribs should be available for those who want to use them. Nonsmoking mothers should not be pressured to abstain from bedsharing with their older infants; they should be provided with accurate, up-to-date scientific information. Infants also should not co-sleep with nonparents. In Oregon, if not elsewhere, the message that smoking mothers should not bedshare is not being disseminated effectively. Because it is not known whether the risk caused by smoking is associated with prenatal smoking, postpartum smoking, or both, bedsharing among either prenatal or postpartum smokers should be strongly discouraged. Much more public and private effort must be made to inform smoking mothers, in culturally competent ways, of the very significant risks of mixing bedsharing and smoking. Public health practitioners need to find new ways to inform mothers and providers that smoking mothers should not bedshare and that putting an infant of a nonsmoking mother to sleep in an adult bed should be delayed until 3 months of age.


Alex N, Thompson JM, Becroft DM, Mitchell EA. 
Pulmonary aspiration of gastric contents and the sudden infant death syndrome. 

Objective: To determine ante-mortem and post-mortem risk factors for the finding of gastric contents in pulmonary airways (aspiration of gastric contents) at post-mortem examination in the sudden infant death syndrome (SIDS). Methods: There were 217 post-neonatal deaths in the Auckland region of the New Zealand Cot Death Study. No deaths were certified as due to aspiration of gastric contents. There were 138 SIDS cases. The parents of 110 (80%) of these cases were interviewed. Histological sections from the periphery of the lungs in 99 of the 110 cases were reviewed for evidence of aspiration of gastric contents. A wide range of variables were analyzed in SIDS cases with and without aspiration to determine risk factors. Results: Aspiration of gastric contents was identified in 37 (37%) of SIDS cases. Aspiration was of mild-to-moderate degree and in no case was severe and a potential cause of death. Finding infants on their backs at death (P = 0.024) and conducting the post-mortem on the day after the death or subsequently (P = 0.033) were statistically significant variables linked to identification of aspiration. Position placed to sleep, symptoms of gastrooesophageal reflux and other variables were not related to aspiration. Conclusions: The only determinants for aspiration of gastric contents identified were agonal or post-mortem events, supporting the contention that aspiration has limited relevance to the mechanism of SIDS.


Malloy MH, MacDorman M. 
Background: Sudden infant death syndrome (SIDS) makes up the largest component of sudden unexpected infant death in the United States. Since the first recommendations for supine placement of infants to prevent SIDS in 1992, SIDS postneonatal mortality rates declined 55% between 1992 and 2001. Objective: The objective of this analysis was to examine changes in postneonatal mortality rates from 1992 to 2001 to determine if the decline in SIDS was due in part to a shift in certification of deaths from SIDS to other causes of sudden unexpected infant death. In addition, the analysis reviews the change in mortality rates attributed to the broad category of sudden unexpected infant death in the United States since 1950. Methods: US mortality data were used. The International Classification of Diseases (ICD) chapters "Symptoms, Signs, and Ill-Defined Conditions" and "External Causes of Injury" were considered to contain all causes of sudden unexpected infant death. The following specific ICD (ninth and tenth revisions) underlying-cause-of-death categories were examined: "SIDS," "other unknown and unspecified causes," "suffocation in bed," "suffocation-other," "aspiration," "homicide," and "injury by undetermined intent." The average annual percentage change in rates was determined by Poisson regression. An analysis was performed that adjusted mortality rates for changes in classification between ICD revisions. Results: The all-cause postneonatal mortality rate declined 27% and the postneonatal SIDS rate declined 55% between 1992 and 2001. However, for the period from 1999 to 2001 there was no significant change in the overall postneonatal mortality rate, whereas the postneonatal SIDS rate declined by 17.4%. Concurrent increases in postneonatal mortality rates for unknown and unspecified causes and suffocation account for 90% of the decrease in the SIDS rate between 1999 and 2001. Conclusions: The failure of the overall postneonatal mortality rate to decline in the face of a declining SIDS rate in 1999-2001 raises the question of whether the falling SIDS rate is a result of changes in certifier practices such that deaths that in previous years might have been certified as SIDS are now certified to other non-SIDS causes. The observation that the increase in the rates of non-SIDS causes of sudden unexpected infant death could account for >90% of the drop in the SIDS rates suggests that a change in classification may be occurring.

Full-text available at: http://www.pediatrics.org (not a U.S. Government site)

Bajanowski T, Vennemann M, Bohnert M, Rauch E, Brinkmann B, Mitchell EA; GeSID Group.

Unnatural causes of sudden unexpected deaths initially thought to be sudden infant death syndrome.


The aim of this clinicopathological study was to determine the frequency of infant deaths due to unnatural causes among cases of sudden and unexpected infant death. Nine institutes of legal medicine in Germany that took part in the German study on Sudden Infant Death Syndrome (GeSID), representing 35% of the German territory, investigated in a 3-year period (from 1998 to 2001) 339 cases of infant death that were not expected to be due to unnatural causes from the first external examination. All cases were investigated by complete, standardized, post-mortem examination including death scene
investigation, autopsy, histology, toxicology and neuropathology. The frequency of unnatural deaths was 5.0% (n=17). The causes of death were head injury (n=7), suffocation (n=5), poisoning (n=2), neglect (n=2) and septicaemia due to aspiration of a foreign body (n=1). Two deaths were unsuspected accidents and 12 were due to infanticide. In 3 cases, it was not possible to differentiate between accidental death and infanticide. A complete postmortem examination including an analysis of the clinical history, death scene investigation, autopsy, histology, toxicology, and neuropathology is mandatory to differentiate sudden and unexpected deaths due to natural causes (e.g. SIDS) and cases of unnatural death.

Full-text available at: http://springerlink.metapress.com/ (not a U.S. Government site)


The Office of the Chief Medical Examiner (OCME) has recorded a significant decline in the deaths of sudden infant death syndrome (SIDS) in the state of Maryland since 1994. However, infants who died of accidental or non-accidental injuries remained consistent during the same time period. This report focuses on the epidemiological characteristics and scene investigation findings of infant victims who died suddenly and unexpectedly in Maryland between 1990 and 2000. A retrospective study of OCME cases between 1990 and 2000 yielded a total of 1619 infant fatalities. 802 infant deaths were determined to be SIDS, which represented 50% of the total infant deaths in our study population. Five hundred and twenty-three (31.8%) deaths were due to natural diseases, 128 (7.9%) deaths were accidents, and 74 (4.6%) were homicides. The manner of death could not be determined after a thorough scene investigation, review of history and a complete postmortem examination in 92 (5.7%) infants. SIDS deaths most often involved infants who were male and black. The peak incidence of SIDS was between 2 and 4 months of age. The majority of SIDS infants (60%) were found unresponsive on their stomach. Among SIDS infants, 269 (33.4%) were found in bed with another person or persons (bed sharing). Of the bed-sharing SIDS cases, 182 (68%) were African-American. In the past 11 years, 52 infants died of asphyxia due to unsafe sleeping environment, such as defective cribs, ill-fitting mattresses, inappropriate bedding materials. Of the 74 homicide victims, 53 (70%) involved infants less than 6 months of age. Twenty (27%) exhibited the classical abuse syndrome characterized by repeated acts of trauma to the infants.


Munchausen syndrome by proxy (MSBP) is a severe and difficult to diagnose form
of child abuse characterized by the simulation, aggravation or production of symptoms of illness in a child by an adult. MSBP often leads to multiple hospitalizations and has a high mortality and long-term morbidity. This study describes the cases of 5 families with 8 children affected who presented with unexplained neurological or gastrointestinal symptoms or even loss of consciousness. All were victims of poisoning or suffocation by their mothers. Two of those children died and were initially diagnosed as SIDS or natural death, respectively. They were only recognized as MSBP victims after another sibling had fallen ill with similar symptoms. The cases are discussed in consideration of the relevant literature. In addition warning signs of this forensically relevant syndrome and a strategy for the management of suspected MSBP cases are described.

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Paluszynska DA, Harris KA, Thach BT. **Influence of sleep position experience on ability of prone-sleeping infants to escape from asphyxiating microenvironments by changing head position.** Pediatrics. 2004 Dec; 114(6):1634-9

Objective: Several studies have found that back- or side-sleeping infants who are inexperienced in prone sleeping are at much higher risk for sudden infant death syndrome (SIDS) when they turn to prone or are placed prone for sleep compared with infants who normally sleep prone. Moreover, such inexperienced infants are more likely to be found in the face-down position at death after being placed prone compared with SIDS infants who are experienced in prone sleeping. We hypothesized that lack of experience in prone sleeping is associated with increased difficulty in changing head position to avoid an asphyxiating sleep environment. Methods: We studied 38 healthy infants while they slept prone. Half of these were experienced and half were inexperienced in prone sleeping. To create a mildly asphyxiating microenvironment, we placed infants to sleep prone with their faces covered by soft bedding. We recorded inspired CO2 (CO2I), electrocardiogram, and respiration, and we videotaped head movements. Also, we assessed gross motor development (Denver Development Scale). Results: When sleeping prone, with their faces covered by bedding, all infants experienced mild asphyxia as a result of rebreathing. All aroused and attempted escape from this environment. Infants used 3 stereotyped head-repositioning strategies. The least effective was nuzzling into the bedding with occasional brief head lifts. More effective were head lifts combined with a head turn. Some infants, however, could turn only to 1 side, right or left. Infants who were inexperienced in prone sleeping had less effective protective behaviors than experienced infants. Infant age did not correlate with efficacy of protective behaviors. Infants who were experienced in prone sleep had advanced gross motor development compared with inexperienced infants. Conclusion: Infants who are inexperienced in prone sleeping have decreased ability to escape from asphyxiating sleep environments when placed prone. These observations potentially explain the increased risk associated with prone sleep in infants who are inexperienced. The increased occurrence of the face-down position in such infants is also potentially explained. These findings suggest that airway protective behaviors may be acquired through the mechanism of operant conditioning (learning).
Three subsequent infanticides covered up as SIDS.
Bohnert M, Grosse Perdekamp M, Pollak S.

Within a period of 9 years a young woman lost 3 daughters during infancy and each time death was attributed to the sudden infant death syndrome. The children had different fathers and died at the ages of 11 weeks, 7 weeks and 2 weeks, respectively. A fourth daughter survived and lives separated from the mother together with her father and is healthy. At autopsy the last of the three deceased infants did not reveal any pre-existing pathological organ findings, except for acute pulmonary emphysema and extensive intra-alveolar bleeding. As a consequence the strong suspicion of mechanical suffocation arose. Subsequent police investigations produced incriminating clues that the first two children had also been suffocated. On confrontation with the autopsy findings and investigation results, the woman confessed that she herself had killed the first two infants by pressing a cushion on their faces. In the case of the third death the baby had been suffocated by the child's father who in agreement with the mother put a plastic film on mouth and nostrils.

Azmitia EC.
Serotoninergic chemoreceptive neurons: A search for a shared function.

When it comes to studying elephants with microscopes, it is helpful, occasionally, to take a few steps back to remind oneself that the whole beast is greater than the sum of its parts. Perhaps the same is true for serotoninergic neurons. In the medulla, serotoninergic neurons function as chemoreceptors. New research indicates that serotoninergic neurons in the midbrain raphe are sensitive to CO(2) concentrations in the blood. Severson and colleagues have suggested that serotoninergic neurons located throughout the brainstem share a similar function: the regulation of systemic pH homeostasis. Most intriguing is the supposition that the dysfunction of these medullary and midbrain serotoninergic neurons might lead to migraine headaches, anxiety or panic disorder, or lack of arousal leading to suffocation, or in the case of infants, sudden infant death syndrome (SIDS).

Unger B, Kemp JS, Wilkins D, Psara R, Ledbetter T, Graham M, Case M, Thach BT.
Racial disparity and modifiable risk factors among infants dying suddenly and unexpectedly.
Background: Racial disparity in rates of death attributable to sudden infant death syndrome (SIDS) has been observed for many years. Despite decreased SIDS death rates following the "Back to Sleep" intervention in 1994, this disparity in death rates has increased. The prone sleep position, unsafe sleep surfaces, and sharing a sleep surface with others (bedsharing) increase the risk of sudden infant death. The race-specific prevalence of these modifiable risk factors in sudden unexpected infant deaths—including SIDS, accidental suffocation (AS), and cause of death undetermined (UD)—has not been investigated in a population-based study. Death rates attributable to AS and UD are also higher in African Americans (AAs) than in other races (non-AA). The potential contribution of unsafe sleep practices to this overall disparity in death rates is uncertain.

Objective: The objective of this study was to compare death rates attributable to SIDS and related causes of death (AS and UD) in AA and non-AA infants and the prevalence of unsafe sleep practices at time of death. Our hypothesis was that there is a large racial disparity in these modifiable risk factors at the time of death, and that public awareness of this could lead to improved intervention strategies to reduce the disparity in death rates.

Methods: In this population-based study, we retrospectively reviewed death-scene information and medical examiners' investigations of deaths in St Louis City and County between January 1, 1994, and December 31, 1997. The deaths of all infants <2 years old with the diagnoses of SIDS, AS, or UD were included. Sleep surfaces other than those specifically designed and approved for infant use were termed nonstandard (adult beds, sofas, etc). Denominators for our rate estimates were the number of births (AA and non-AA) in St Louis City and County during the study period. Results: The deaths of 119 infants were studied (81 AA and 38 non-AA). SIDS rates were much higher in AA than non-AA infants (2.08 vs 0.65 per 1000 live births), as was the rate of AS (0.47 vs 0.06). There was a trend for increased deaths diagnosed as UD in AA infants (0.36 vs 0.06). Bedsharing deaths were nearly twice as common in AAs (67.1% vs 35.1% of deaths), as were deaths on nonstandard sleep surfaces (79.0% vs 46.0%). Forty-nine percent (49.1%) of all infants who died while bedsharing were found on their backs or sides compared with 20.4% of infants who were not bedsharing. Overall, the fraction of infants found in these nonprone positions was not different for AA infants and non-AA infants (43.3% vs 38.5%). In AA and non-AA infants, factors that greatly increase the risk of bedsharing, such as sofa sharing or all-night bedsharing, were present in all or many bedsharing deaths. Conclusion: Among AA infants dying suddenly and unexpectedly, the high prevalence of nonstandard bed use and bedsharing may underlie, in part, their increased death rates. Public health messages tailored for the AA community have stressed first and foremost using nonprone sleep positions. The observation that there was no difference between AA and non-AA infants in position found at death suggests that racial disparity in sleep position is not the most important contributor to racial disparity in death rates. The finding that more infants died on their back or side while bedsharing than otherwise suggests that these sleep positions are less protective when associated with bedsharing. We conclude that public health information tailored for the AA community should give equal emphasis to risks and alternatives to bedsharing as to avoidance of the prone position.

Full-text available at: http://www.pediatrics.org (not a U.S. Government site)

**Analysis of SIDS-related civil and criminal court cases in Japan.**

Thirty-three sudden infant death syndrome (SIDS)-related civil and criminal lawsuits in Japan were retrieved from judicial precedent databases "Hanrei Masutar (Judicial Decisions Master)" and "Hanrei Taikei (Judicial Decisions System) using "SIDS" as a keyword. Sleeping posture and developmental stage of occurrence were studied in each of the cases retrieved, whether or not a legal autopsy had been performed. The influence exerted on court decisions by Japanese definitions of SIDS as well as the relationship between causes of death and court decisions were studied. Of 33, two were criminal cases (business/professional negligence on the part of the defendants, leading to death), and the rest were civil cases (claims for damages). Because the decision handed down in both criminal cases was "cause of death unknown", these defendants were found innocent. One of these cases was argued in both the court of appeals and the superior court: these courts found SIDS to be the cause of death and consequently the claim for damages was rejected. Both criminal and civil courts dealt with another case: the former found the cause of death to be "unknown" and the defendant innocent, while the latter, finding SIDS the cause of death, declined to review. In cases where the sleeping posture was prone, courts tended to decide the cause of death to be suffocation, especially with neonates. Because diagnosis by exclusion is required in cases of a legal autopsy for SIDS, the diagnosis is difficult without an autopsy. Disagreements between the results of legal autopsy and court decisions occurred in eight cases. With such a discrepancy, a detailed case examination is necessary. In 1983, SIDS was defined in Japan in two different ways; one in a more strict sense and the other being more inclusive. The wider and narrower definitions were unified in 1995 by requiring a survey of the circumstances of death in addition to the narrower definition. Because of this situation, the two cases in the 1980s when legal autopsy was not enforced fell into the category of "SIDS in a wider sense." In no case was a defendant found guilty when the cause of death was judged to be either SIDS/ALTE or unknown. Four cases were rejected when the cause of death was judged to be neither due to suffocation nor SIDS, while seven were accepted either as cases of "joint faults that canceled each other," or as "partial acceptance." In Japan, official views concerning a SIDS diagnosis differ among pediatricians, legal scholars of forensic medicine and pathologists. These differences appeared to influence the legal decisions. Several conferences should be convened as soon as possible to provide an opportunity to resolve the main points of difference between these three professional groups and, thus, attain a unified view.

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Truman TL, Ayoub CC.

**Considering suffocatory abuse and Munchausen by proxy in the evaluation of children experiencing apparent life-threatening events and sudden infant death syndrome.**
This study describes 138 young children admitted to the hospital over a 23 year period for recurrent apparent life threatening events (ALTEs), unexplained deaths, or with Sudden Infant Death Syndrome (SIDS)-related diagnoses. In examining the potential for suffocatory abuse in living children, we utilized characteristics in the literature that distinguish SIDS or ALTEs due to natural disease states from abuse. Findings demonstrate a co-occurrence of risk factors that raise suspicions of suffocatory abuse or Munchausen by Proxy. Of the 35 children who died, SIDS was the presumed clinical diagnosis at the time of death in 71% of the cases. Comprehensive chart review and autopsy findings revealed a non-SIDS diagnosis in 54% and confirmed or suspicious child abuse in 37% of these deaths. Reports to Child Protective Services were made in 6% of cases. Recommendations for assessment of children including attention to risk indicators, involvement of child protection teams, mandatory autopsies, and each scene investigations are offered.

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Malloy MH.
Trends in postneonatal aspiration deaths and reclassification of sudden infant death syndrome: impact of the "Back to Sleep" program.

Objective: The introduction of the "Back to Sleep" campaign for the prevention of sudden infant death syndrome (SIDS) brought with it concern that there might be an increase in the incidence of aspiration-related deaths. The objective of this analysis was to describe the trends in postneonatal mortality and proportionate mortality ratios for the United States for the years 1991 to 1996 for aspiration-related deaths and other causes to which a SIDS death could conceivably be reclassified. Methods: Linked birth and infant death vital statistic files for the United States were used for the years 1991, 1995, and 1996. US Vital Statistic Mortality files for the years 1992, 1993, and 1994 were used because of the absence of linked files for those years. Results: The overall postneonatal mortality rate between 1991 and 1996 declined 21.9%, whereas the SIDS rate declined 38.9%. The proportion of the postneonatal mortality (PNPMR) contributed by SIDS declined from 37.1% in 1991 to 28.8% in 1996. There was no significant increase in the PNPMR for aspiration, asphyxia, or respiratory failure. There was, however, a significant increase in the PNPMR for suffocation in bed or cradle from 0.9 to 1.3. Conclusions: These data show no evidence of an increased risk of death from aspiration as a result of the "Back to Sleep" program. Although there has been an increase in the proportion of postneonatal mortality attributable to suffocation, this represents a very small proportion of postneonatal mortality and thus potentially a very small number of SIDS deaths reclassified as suffocation.

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Person TL, Lavezzi WA, Wolf BC.
Cosleeping and sudden unexpected death in infancy.
Context: The practice of infants cosleeping with adults has long been the subject of controversy. Autopsy findings in cases of sudden infant death syndrome (SIDS) are usually indistinguishable from those found with unintentional or intentional suffocation, and the determination of the cause of death in cases of sudden unexpected death in infancy is often based on investigative findings and the exclusion of natural or traumatic causes. Objective: To further elucidate the risk of cosleeping. Methods: We reviewed 58 cases of sudden unexpected infant deaths. Cases were excluded if there was any significant medical history or evidence of trauma or abuse. Results: Twenty-seven of the infants were cosleeping. Eleven of these cases had been previously diagnosed as SIDS, and in 7 cases parental intoxication was documented. Conclusion: Our findings support recent studies that suggest that cosleeping or placing an infant in an adult bed is a potentially dangerous practice. The frequency of cosleeping among cases diagnosed as SIDS in our study suggests that some of these deaths may actually be caused by mechanical asphyxia due to unintentional suffocation by the co sleeping adult and/or compressible bedding materials.