Aspiration and Sudden Infant Death syndrome (SIDS): A Selected Annotated Bibliography


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It has been asserted that hypoxic-ischemic encephalopathy (HIE) with cerebral swelling in the absence of marked trauma may be responsible for subdural hemorrhage in the young. As this may have considerable implications in determining both the mechanism of death and the degree of force required to cause injury in certain cases of inflicted head injury in infancy, clarification is required. A retrospective study of 82 fetuses, infants and toddlers with proven HIE and no trauma was undertaken from forensic institutes in Australia, the United Kingdom, Germany, Denmark and the United States. The age range was 35 weeks gestation to 3 years, with a male to female ratio of 2:1. All cases had histologically-confirmed HIE. Causes of the hypoxic episodes were temporarily resuscitated sudden infant death syndrome (SIDS) with delayed death (N = 30), drowning (N = 12), accidental asphyxia (N = 10), intrauterine/delivery asphyxia (N = 8), congenital disease (N = 6), aspiration of food/gastric contents (N = 4), inflicted asphyxia (N = 3), epilepsy (N = 1), dehydration (N = 1), drug toxicity (N = 1), complications of prematurity (N = 1), and complications of anesthesia (N = 1). In four instances the initiating event was not determined. In no case was there macroscopic evidence of subdural hemorrhage. In this study no support could be given to the hypothesis that HIES in the young in the absence of trauma causes subdural hemorrhage.

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

Krous HF, Masoumi H, Haas EA, Chadwick AE, Stanley C, Thach BT.

Aspiration of gastric contents in sudden infant death syndrome without cardiopulmonary resuscitation.

Objectives: (1) To compare demographic profiles among sudden infant death syndrome (SIDS) infants with or without gastric aspiration, for whom cardiopulmonary resuscitation (CPR) had not been attempted; (2) to review the severity and potential significance of aspiration in those SIDS cases; and (3) to assess the risk of supine sleep position with regard to gastric aspiration. Study Design: Retrospective review of records and microscopic slides for all post neonatal SIDS cases (29 to 365 days of age) accessioned by the San Diego County Medical Examiner from 1991 to 2004. Results: Ten (14%) of 69 cases of SIDS infants who had not undergone CPR before autopsy.

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revealed microscopic evidence of gastric aspiration into the distal lung; this group was not otherwise clinically or pathologically different from cases of SIDS infants without aspiration. Similar proportions of infants were found supine or prone, regardless of gastric aspiration. Conclusions: Gastric aspiration is not uncommon in infants dying of SIDS, and supine sleep position does not increase its risk. Gastric aspiration may be a terminal event that some infants, representing a subset of SIDS cases, cannot overcome.


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.

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**Sudden Unexpected child deaths: forensic autopsy results in cases of sudden deaths during a 5-year period.**

The aim of the present study was to determine the incidence of various causes of sudden unexpected child deaths (SUCD) and to assess the importance of an autopsy in predicting the likelihood of finding a cause of death. A retrospective analysis of autopsy findings in 97 cases of SUCD between the ages of 0--11 years was undertaken at the Council of Forensic Medicine, Ankara during a 5-year period (1995--2000). Cases were classified as explained causes (80.42 per cent) and sudden infant death syndrome (SIDS) (19.58 per cent). A total of 25.77 per cent of the deaths occurred in the neonatal period, 45.31 per cent of them in the first year of life and the remaining 28.86 per cent after 1 year of life. The causes of neonatal deaths were respiratory pathology (five cases), birth
complications (four cases), gastrointestinal pathology (one case), homicide (10 cases), and SIDS (five cases). The incidence of SIDS in the newborn period was 33 per cent. The incidence of unexplained causes of deaths in the postneonatal period was 31 per cent and the causes of deaths were respiratory pathology (15 cases), aspiration (five cases), gastrointestinal pathology (four cases), SIDS (14 cases), and other causes (four cases). The study of an entire population provides more reliable data regarding causes of sudden unexpected child deaths than does the study of small groups and it is also recommended that in addition to a thorough evaluation, a detailed autopsy must be performed for each case in experienced centers.


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, standarised, 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.

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Heininger U, Kleemann WJ, Cherry JD; Sudden Infant Death Syndrome Study Group.

**A controlled study of the relationship between Bordetella pertussis infections and sudden unexpected deaths among German infants.**


Objective: This was a prospective, controlled, multicenter study to investigate the relationship between Bordetella pertussis infections and sudden unexpected deaths among German infants. Design: Between 1995 and 1997, all infants who died at 7 to 365
days of age and for whom autopsies were performed in 1 of 8 participating institutes of legal medicine were enrolled. During a standardized autopsy, nasopharyngeal specimens (NPSs) and tracheal specimens were obtained for polymerase chain reaction (PCR) assays to detect B pertussis. The oligonucleotide primers PTp1 and PTp2, which specifically amplify a 191-base pair DNA fragment of the pertussis toxin operon of B pertussis, were used. Two control subjects (matched according to residence, age, gender, and nationality) were enrolled for each case subject, via a network of pediatricians in private practice, and NPSs were obtained from those infants. Parents of case subjects and control subjects were asked to provide specific information on respiratory illnesses of the child, contact with a known case of pertussis, or close contact with a person with a cough illness during the 4 weeks before death or enrollment, as well as the child's pertussis immunization status. The pathologists performing the autopsies were unaware of the PCR results. Results: Enrolled were 254 infants (66% male) with sudden unexpected deaths and 441 matched control subjects. Autopsies according to protocol were performed for 234 of the case subjects (92%); a diagnosis of sudden infant death syndrome (SIDS) was made for 76%. For the remaining subjects, causes of death were respiratory or other infections (14%), congenital anomalies or organ failures (4%), aspiration (2%), or accidents or traumatic events (4%). PCR results were positive for B pertussis for 12 case subjects (5.1%) (all with SIDS or respiratory infections) and 5.3% of control subjects. Of the 12 case subjects with positive PCR results, 10 (83%) were male. Questionnaires had been returned by the parents of 5 of the 12 infants. Three had experienced a respiratory illness (all with cough), beginning 7, 14, and 19 days before death. None had a known contact with a case of pertussis. Four of 15 control infants (27%) with positive PCR findings for B pertussis had a cough illness, indicating possible pertussis, and 2 of those 4 developed typical symptoms (whooping). Background information was received from 116 parents (46%) of case subjects and from parents of all control subjects. Upper respiratory tract infections within 4 weeks before death were reported for 53% of case subjects and 38% of control subjects. Also, fewer case subjects (33%) than control subjects (68%) had received age-adequate numbers of pertussis vaccine doses.

Conclusions: The concept of infection as a factor in SIDS is supported by a number of observations, including the seasonal distribution of the occurrence of SIDS; the high incidence of concurrent upper respiratory tract infections among infants dying as a result of SIDS; the peak age at 3 to 4 months; nicotine use in a child's household, which predisposes children to respiratory infections such as otitis media; and the protective role of breastfeeding. A prominent role might be suspected for B pertussis, for several reasons. 1) B pertussis infections in infancy are frequently associated with apneic spells, which are occasionally life-threatening and, if leading to death, might be reported as SIDS. 2) Epidemiologic evidence from the United Kingdom, Sweden, and Norway indicates that SIDS is associated with B pertussis infection. 3) In a previously published study, we detected B pertussis DNA in the nasopharynx of 9 of 51 consecutive infants (18%) with sudden unexpected deaths. This is the first prospective, controlled study to investigate the possible etiologic role of B pertussis in SIDS. Clinically unrecognized B pertussis infections were relatively frequent (5.3%) among control infants during the course of our study. The rate of infection was similar or perhaps greater for control subjects, compared with case subjects (1.7%), when only NPS results were compared. This may seem surprising but is supported by other studies, in which asymptomatic
infections or mild respiratory illnesses were observed among infants exposed to B pertussis. Careful autopsies, including histologic evaluations of organ specimens and use of PCR to detect B pertussis in NPSs and tracheal specimens, represented a strength of this study. Our general findings were as expected. The majority of cases were classified as SIDS. The second largest group included infants for whom respiratory infections were found. The findings of various other diagnoses, which in several instances would have been undiscovered otherwise, emphasize the need for autopsies after unexpected infant deaths. What is the significance of the identified B pertussis infections in 12 cases? Several pieces of evidence support the plausibility of a cause-and-effect relationship. Eight of the 12 case subjects died before 6 months of age, the typical age for death attributable to pertussis. In autopsies, 9 of the subjects were found to have signs of respiratory infections; for 2 infants, the autopsies suggested that death was attributable to a respiratory infection. One additional infant (data not shown) had brain edema (which could have been attributable to hypoxemia during pertussis). Lower rates of completed primary series or age-adequate numbers of pertussis vaccine doses among case subjects than among control subjects may indicate that immunization against pertussis protects children from death attributable to unrecognized B pertussis infection. Moreover, a recent study indicated that immunization with diphtheria-tetanus-pertussis vaccine induces antibodies that cross-react with pyrogenic staphylococcal toxins, which have been implicated in several cases of SIDS. Other microorganisms may be involved in the sudden death of infants, as suggested in this study by the higher rate of a history of concurrent upper respiratory tract infections among case subjects, compared with control subjects. Similarly, in a Scandinavian study, 48% of 244 SIDS case subjects, compared with 31% of 869 control subjects, exhibited symptoms of upper airway infection during the last week before death or interview, respectively. Because SIDS is a diagnosis of exclusion, every attempt should be made to identify a cause of death during autopsy. This should include the search for pathogenic microorganisms in the respiratory tract with the use of PCR and other sensitive tests. In conclusion, B pertussis infection was found for 12 of 234 infants (5.1%) with unexpected deaths, and the infections might have contributed to the deaths.

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Bullock LF, Mickey K, Green J, Heine A.

Are nurses acting as role models for the prevention of SIDS.

Purpose: To examine nurses' knowledge, attitude, and practice in positioning healthy newborns for sleep in the hospital setting. Design and Methods: A cross-sectional descriptive design was used to survey a convenience sample of practicing maternal child nurses in 58 Missouri hospitals. A 24-item investigator designed questionnaire was developed with input from SIDS Resources in Missouri. Results: A total of 528 surveys were analyzed. These nurses reported no longer placing infants in the prone position for sleep, but almost 75% of those answering the survey used either the side-lying position or a mixture of side and back positioning, even though 96% of the nurses said they were aware of the AAP Guidelines recommending "back to sleep." Forty-five percent of the
nurses thought the infant would be at risk for aspiration if only placed on his/her back. Only 53% of the nurses knew their hospital's policy about newborn positioning; 80% of those who knew about the policy said it included the lateral position as being acceptable practice. Clinical Implications: Nurses are the role models for new parents regarding newborn sleep position, and are in a unique position to influence parents’ decisions about how to place their infants for sleep at home. Because nurses continue to worry about aspiration when newborns are placed on their backs, it is clear that more education is needed for hospital nurses about newborn sleep position and hospital policies, as well as AAP Guidelines.


Background: Although advice from healthcare professionals may influence parental infant placement choice to reduce sudden infant death syndrome risk, literature on nursery staff infant placement behaviors and the degree to which they influence maternal infant sleep positioning is limited. Objective: To assess newborn placement practices of the mother and nursery staff and their interrelationship in the hospital setting. Methods: A cross-sectional survey-based study was conducted among hospital newborn nursery staff (n = 96) and mothers of newborns (n = 579) at eight perinatal hospitals in Orange County, California. RESULTS: Although a majority of sampled nursery staff (72%) identified the supine position as the placement that most lowers sudden infant death syndrome risk, only 30% reported most often placing infants to sleep in that position, with most staff (91%) citing fear of aspiration as the motivation for supine position avoidance. Only 34% of staff reported advising exclusive supine infant positioning to mothers. Approximately 36% of mothers reported using supine infant placement exclusively. Maternal infant placement choice varied by both the advice (p <.01) and the placement modeling (p <.01) provided by staff, with the highest proportion of usual supine infant placement found among mothers who reported receiving both. A mother's race/ethnicity also affected the reception of exclusive supine placement recommendations (p <.01). Conclusions: Exclusive supine infant placement appears to be underused by both nursery staff and mothers of newborn infants. Culturally grounded educational intervention with nursery staff regarding infant positioning and placement in the hospital setting is indicated.

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It is a well-recognized fact among professionals that the diagnosis of sudden infant death syndrome (SIDS) involves difficult elements; a SIDS diagnosis is not uniform throughout Japan; and such a diagnosis is not made based on any internationally recognized
definition. Faced with this situation, guidelines have been prepared and proposals have been made to standardize and improve the accuracy of SIDS diagnoses, viz. the following three can be cited: "guideline for diagnosis of SIDS" prepared by a Study Group of the Ministry of Health and Welfare; "case studies of SIDS" and a "guideline for its diagnosis" prepared by the Case Study Committee of Japan SIDS Research Society; and a "proposal on the principles of medico-legal pathology concerning SIDS", included in the research report supported by a Grant-in-Aid for Scientific Research from the Ministry of Education. In the current study, a comparison was made focusing on the discrepancies among these three documents. The major discrepancies among these three are: (1) handling of the patient's age (by months or years) in the diagnosis of SIDS; (2) dealing with those cases for which no autopsy has been conducted; (3) attitudes concerning whether sleeping in a prone posture is a cause for asphyxia and (4) opinions concerning the aspiration of vomited milk. It is anticipated that these discrepancies will invite confusion and affect judgments and recognition of SIDS-related cases that will be brought to court. It is essential that those involved with these three documents have an opportunity at the earliest time to discuss the matter and come to a uniform understanding.


This is a retrospective survey of findings of myocarditis in 437 infants under the age of 1 year who died suddenly and unexpectedly between 1982 and 1999, and were investigated at the Department of Forensic Medicine in Stockholm, Sweden. Myocarditis was diagnosed in 69/410 infants who died naturally (16.8%) and in 2/27 violent deaths (7.4%). In 43/410 natural deaths (10.5%) the myocarditis was an isolated finding and the only explanation for cause of death and in 26 (6.3%) there were additional possible causes of death. The myocarditis was acute in 45/69 and chronic in 24/69 natural deaths, and was found to occur as early as at a few weeks of age. No specific risk factors were found when reviewing critical time of year, age, gender, previous symptoms, sleeping position, aspiration of gastric contents and environmental factors in infant deaths with finding of myocarditis compared to 313 deaths due to sudden infant death syndrome. Myocarditis was found in 13 of 37 deaths where cultures for cytomegalovirus were positive. More than 50% of the foci of the isolated myocarditis were located in the upper part of the interventricular septum and the adjacent part of the right atrium, areas including parts of the conduction system. This localisation is significant for the cause of death when comparing deaths with myocarditis as an isolated finding to deaths with other possible causes.

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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.
Objectives: 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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Klonoff-Cohen HS, Srinivasan IP, Edelstein SL.

**Prenatal and intrapartum events and sudden infant death syndrome.**


The purpose of this study was to evaluate specific pregnancy and labour and delivery events that may increase the risk of sudden infant death syndrome (SIDS). A matched case-control study was conducted in five counties in southern California, using California death certificate records. The sample consisted of 239 Caucasian, African-American, Hispanic and Asian mothers of SIDS infants and 239 mothers of control infants matched on sex, race, birth hospital and date of birth. Mothers participated in a detailed telephone interview and provided access to obstetric and paediatric records. More case than control mothers reported a family history of anaemia (OR=2.12, P < 0.001). Placental abruptions were strongly associated with SIDS (unadjusted OR=7.94, [95% CI 1.34,47.12]). There was an increased risk of SIDS death associated with maternal anaemia during pregnancy (OR=2.51, [95% CI 1.25,5.03]), while simultaneously adjusting for maternal smoking during pregnancy, maternal years of education and age, parity, infant birthweight, gestational age, medical conditions at birth, infant sleep position and post-natal smoking. Interactions of anaemia and prenatal smoking as well as anaemia and post-natal smoking were not statistically significant. There were no other statistically significant differences between case and control mothers for pregnancy conditions, labour and delivery events (e.g. caesarean sections, anaesthesia, forceps) or newborn complications (e.g. nuchal cord, meconium aspiration). Anaemia and placental abruptions were significantly
associated with an increased risk of SIDS; both are circumstances in which a fetus may become hypoxic, thereby compromising the subsequent growth, development and ultimate survival of the infant.

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