Int J Legal Med (2005) 119: 213–216
DOI 10.1007/s00414-005-0538-8

ORIGINAL ARTICLE

**T. Bajanowski · M. Vennemann · M. Bohnert · E. Rauch · B. Brinkmann · E. A. Mitchell · GeSID Group**

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

Received: 5 November 2004 / Accepted: 4 March 2005 / Published online: 14 April 2005


**Abstract** 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, standardised, 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.

**Keywords** Sudden infant death syndrome (SIDS) · Unnatural infant death · Infanticide

Contributors at Institutes of Legal Medicine: U. Deml, Friedrich-Alexander-University, Erlangen; A. Freislederer, University Duisburg-Essen, Essen; S. Heide, Martin-Luther-University, Halle; H.-J. Kaatsch, S. Ritz-Timme, Christian-Albrechts-University, Kiel; K.-P. Larsch, A. Fiegut, Medizinische Hochschule Hannover, Hannover; H.W. Leukel, Johann-Wolfgang-Goethe-University, Frankfurt am Main; C. Ortmann, Friedrich-Schiller-University, Jena; R. Penning, Ludwig-Maximilians-University, Munich.

T. Bajanowski (✉)
Institute of Legal Medicine, University Hospital Essen,
University of Duisburg-Essen,
Hufelandstr. 55,
45122 Essen, Germany
e-mail: Thomas.Bajanowski@medizin.uni-essen.de
Tel.: +49-201-7133600
Fax: +49-201-7235940

M. Vennemann
Institute of Epidemiology,
University of Münster,
Münster, Germany

M. Bohnert
Institute of Legal Medicine,
Albert-Ludwigs-University,
Freiburg, Germany

E. Rauch
Institute of Legal Medicine,
Ludwig-Maximilians-University,
Munich, Germany

B. Brinkmann
Institute for Legal Medicine,
University of Münster,
Münster, Germany

E. A. Mitchell
Department of Paediatrics,
University of Auckland,
Auckland, New Zealand

## Introduction

The investigation of sudden unexpected death of infants is difficult. After a thorough investigation at least three entities can be described: (1) one group of cases lacking clinical symptoms as well as significant pathological findings, which has been designated sudden infant death syndrome (SIDS) and which is still believed to be of common but unknown etiology; (2) cases with known and internationally accepted cause of death, but the related diseases were lacking serious preceding symptoms or were not recognised as such; (3) between these extremes is a group of "borderline" SIDS with mild or intermediate findings not considered to be a sufficient cause of death. All three subgroups can become complicated by the admixture of unnatural deaths. These include deaths due to suffocation, but lacking external lesions because oronasal occlusion has occurred by soft cover-

ing, and deaths due to poisoning by drugs or other substances that have been administered but not identified. This is made more complex by the occurrence of unnatural mechanisms in the presence of mild pre-existing changes that are held responsible for the cause of death.

Although there is a wide range of estimated frequency of deaths due to suffocation (between 0.6 and 10%) [1, 4] and a considerable number of cases of infanticide that were originally diagnosed as SIDS [5], an autopsy is performed in Germany in about 50% of the sudden and unexpected infant deaths only [8].

The aim of this study was to examine the circumstances and causes of unnatural deaths in infants dying suddenly and unexpectedly that on initial external assessment were thought to be from natural causes. In addition, the value of different diagnostic instruments will be analysed and the number of unrecognised infanticides will be estimated for Germany.

## Material and methods

The German SIDS study was a case–control study with 18 centres participating [14]. Unnatural deaths were recorded systematically as a substudy in nine centres. The other nine centres did not record the information on unnatural deaths or permission was not granted to send the information to the national study centre. The nine participating centres in this report cover 35% of all births in Germany. The study period was from November 1998 to October 2001. Cases younger than 8 days or 1 year of age or older were excluded from the study.

In Germany the first external examination is usually done by an emergency doctor, general practitioner or paediatrician. If any suspicious finding was seen the case was referred to the prosecutor and was not included in the GeSID study. Similarly, cases that were suspected as being due to an accident based on the death scene examination by the police

**Table 1** Case description: cause of death and mechanism of death, main findings, and critical diagnostic instruments

| Case no. | Cause of death | Mechanism | Case description | Critical diagnostic instruments |
|---|---|---|---|---|
| 1 | Septicaemia | Accident | Aspiration of foreign body with necrotising pharyngitis and septicaemia | Macro. exam., microbiology |
| 2 | Suffocation | Accident | Aspiration of foreign body with airway occlusion | Macro. exam. |
| 3 | Dehydration | Unclarified | Neglect, subileus | Macro. exam. |
| 4 | Dehydration, | Unclarified | Neglect, failure to thrive | Macro. exam. |
| 5 | Poisoning | Unclarified | Heroin poisoning, heroin-dependent mother | Toxicology |
| 6 | Head injury | Infanticide | Small haematoma of the scalp, intracerebral haemorrhage, pneumonia | Macro. exam., neuropath., histology |
| 7 | Suffocation | Infanticide | Repeated soft covering or external airway occlusion, lung siderosis | Macro. exam., histology |
| 8 | Suffocation | Infanticide | External mechanism of suffocation | Macro. exam., histology[a] |
| 9 | Suffocation | Infanticide | Soft covering, respiratory tract infection | Macro. exam., histology[b] |
| 10 | Suffocation | Infanticide | Compression of the neck—3 small haematomas in the muscles of the neck, multiple fractures at different stages of healing | Macro. exam., X-ray |
| 11 | Head injury | Infanticide | Subdural haemorrhage | Macro. exam., neuropath. |
| 12 | Head injury | Infanticide | Haematoma of the scalp, severe brain oedema, respiratory tract infection | Macro. exam., histology, neuropath. |
| 13 | Head injury | Infanticide | Subdural haemorrhage, pneumonia | Macro. exam., histology, neuropath. |
| 14 | Head injury | Infanticide | Subdural haemorrhage, generalised viral infection | Macro. exam., histology, virology, neuropath. |
| 15 | Head injury | Infanticide | Retinal haemorrhages, subdural haemorrhage, severe brain oedema | Macro. exam., neuropath. |
| 16 | Head injury | Infanticide | Small haematoma of the scalp, subdural haemorrhage, brain oedema | Macro. exam., neuropath. |
| 17 | Poisoning | Infanticide | Promethazine poisoning, focal pneumonia | Toxicology, histology |

*Macro. exam.* macromorphological examination, *neuropath.* neuropathology

[a] In case 8, severe congestion of the conjunctivae was found. Lung histology showed severe congestion, intraalveolar, septal and subpleural haemorrhages, and severe acute emphysema; other organs: no pathological changes. The suspicion "external suffocation" has been confirmed by the perpetrator's confession.

[b] This infant suffered from cough and cold 2 days prior to death. Histology: mild pharyngitis, tracheitis; lung histology: acute congestion of the blood vessels, haemorrhagic oedema of the alveoli and the alveolar walls, microhaemorrhages, septal and subpleural haemorrhages, severe acute emphysema, microembolism (mainly bone marrow cells); other organs: unspecific changes. Confession of the perpetrator: occlusion of nose and mouth

**Table 2** Causes and mechanisms of unnatural death

| Cause of death | Accidental | Unclarified | Infanticide | Total (*n*) |
|---|---|---|---|---|
| Neglect | 0 | 2 | 0 | 2 |
| Suffocation | 1 | 0 | 4 | 5 |
| Poisoning | 0 | 1 | 1 | 2 |
| Head injury | 0 | 0 | 7 | 7 |
| Other | 1 | 0 | 0 | 1 |
| Total (*n*) | 2 | 3 | 12 | 17 |

were not enrolled. Thus, the cases that were enrolled into this study were sudden and unexpected infant deaths that were initially thought to be from natural causes.

The study manual was in accordance with the European guidelines for medico-legal autopsies [15] and closely reflects the international standardised autopsy protocol [2]. The death scene investigation was performed by police officers in all cases, and in some areas as well as in selected cases by a specialist in legal medicine. The autopsy included a thorough external examination, complete internal examination, extensive histology, microbiology, PCR-based virology, neuropathology, clinical chemistry if indicated and a full analytical toxicology scheme. Before the autopsy, an X-ray investigation of the whole body was performed. The final diagnosis was made in an interdisciplinary case conference at the study centre.

## Results

There were 339 infant deaths that were registered in the study from the nine centres. Of these 339 cases, 292 (86.1%) were classified as SIDS. In 30 (8.8%) cases a morphologically defined natural cause of death was found and in 17 (5.0%), an unnatural cause of death.

The average age of these 17 infants was 4.0 months (range, 3–51 weeks). Nine of the cases were male (52.9%).

Analysis of the individual cause, mechanism and description of the unnatural deaths (Table 1) shows that the most frequent causes of death were head injury (*n*=7) and suffocation (*n*=5). Poisoning (*n*=2), neglect (*n*=2), and septicaemia (*n*=1) accounted for the other cases.

Two deaths were unsuspected accidents and 12 were due to infanticide (Table 2). Thus, the incidence of infanticide, which initially was suspected as SIDS or natural cause, was 3.5% in this study. In about 20% of the unnatural deaths (*n*=3) it was not possible to differentiate between accidental death and infanticide.

Table 1 summarises the critical diagnostic instrument for the identification of the cause and mechanism of death. All cases of head injury were identified by the macroscopic examination of the brain and completed by neuropathology/histology. Histology is necessary in each case to identify pre-existing diseases and to estimate the time of violence prior to death. In cases of suffocation it can be indicative of the cause of death.

## Discussion

In this study, infant death due to infanticide initially thought to be due to SIDS was rare (3.5%). Even if those cases where it was not possible to determine whether the death was due to an accident or infanticide are classified as infanticide, then the incidence was still only 4.4%. This figure is similar to the Westphalian cot death study conducted in 1990–1995, which found 8 cases of unsuspected infanticide among 274 cases of sudden and unexpected death (2.9%) [10]. This result is in contrast to Krous et al. [3], who found that the ratio of infanticide to SIDS increased in California from 4.3 to 10.2% over a period of 18 years. These differences can be explained by a different period and a different study design (these authors analysed all infanticides, not only those that were detected among cases presenting as SIDS).

This study illustrates the need for a complete post-mortem examination in order to identify the 5% of unnatural deaths that are unexpected. However, it should be emphasised that in about a quarter of unnatural deaths the mechanism (accidental or inflicted) may not always be apparent despite this extensive investigation. In particular, the detection of suffocation due to soft covering or external airway occlusion can be difficult [1, 4, 6, 10]. Small lesions in the skin of the neck or face as well as histological findings in the lungs (e.g. acute emphysema, congestion of blood vessels, alveolar and septal haemorrhages) should leave a wake of suspicion. In the present series, this suspicion was confirmed in two of three cases by the police investigation (Table 1, cases 9 and 10), whereas in case 6 the mechanism leading to death remained unclear.

The international standardised autopsy protocol [2] has become the recognised standard for the post-mortem examination of sudden unexpected deaths in infancy [11]. However, the value of the individual components of the protocol has not been systematically studied. Toxicology was essential to detect the two cases of poisoning that would not have been recognised otherwise. Whole-body radiograph was a useful confirmatory diagnostic tool in one case of infanticide (before autopsy), but did not lead to a diagnosis of infanticide that would not have been identified by other means. The cases of infanticide from head injury would be difficult to detect without macroscopic examination of the brain. This argues against the suggestion of a limited autopsy [12] not including the brain. These results demonstrated that an external examination of the infants body is essential but often not sufficient to recognize cases of unnatural death. This is particularly true for infants who died due to suffocation or head injury. These two types of violence were the cause of death in 10 of 11 infanticides. External changes/injuries such as petechial haemorrhages in the eyelids, the conjunctivae or the skin of the head, minor excoriations or blood-tinged fluid around the mouth and nose are rare [4–7]. In cases of shaken baby syndrome, small haematomas of the skin of the chest or of the extremities can be the only visible injury and are unspecific [7].

In Germany, 8,332 cases were officially registered as SIDS in the 10-year period from 1990 to 1999 [13]. An

autopsy was performed in about 50% of these cases [8]. Furthermore, of those that were autopsied, additional investigations such as histology, neuropathology and toxicology were not routine. If these data were applicable to those that were essentially uninvestigated (4,166 not autopsied), then there would have been on average 21 unidentified unnatural deaths per year of which there would be 14 infanticides per year. This argues strongly for a complete autopsy in all cases of sudden unexpected death in infancy. It has to be stressed that it is the primary task of the specialist in legal medicine and not that of the prosecutor to decide which investigations are necessary. Even if a complete investigation had been performed, in about 20% of the cases of unnatural death differentiation between accidental and homicidal mechanisms cannot be determined. If the suspicion cannot be confirmed without any reasonable doubt, e.g. by the police investigations, the parents have to be presumed innocent.

## Conclusion

Unsuspected unnatural deaths are rare (5.0%) among infants who die suddenly and unexpectedly that are suspected of dying from natural causes. A complete post-mortem investigation is essential to detect cases of unnatural death as well as infanticides.

**Acknowledgements** The study is supported by the German Ministry of Science and Education (01 ED 9401).

## References

1. Kukull WA, Peterson DR (1977) Sudden infant death and infanticide. Am J Epidemiol 106:485–486
2. Krous H (1996) Instruction and reference manual for the International Standardised Autopsy Protocol for sudden unexpected infant death. J SIDS Infant Mortal 1:203–246
3. Krous HF, Nadeau JM, Silva PD, Byard RM (2002) Infanticide: is its incidence among postneonatal infant deaths increasing?: an 18-year population based-analysis in California. Am J Forensic Med Pathol 23:127–131
4. Becroft DM, Thompson JM, Mitchell EA (2001) Nasal and intrapulmonary haemorrhage in sudden infant death syndrome. Arch Dis Child 85:116–120
5. Betz P, Hausmann R, Eisenmenger W (1998) A contribution to a possible differentiation between SIDS and asphyxiation. Forensic Sci Int 91:147–152
6. Bohnert M, Große Perdekamp M, Pollak S (2005) Three subsequent infanticides covered up as SIDS. Int J Legal Med 119:31–34
7. Lancon JA, Haines DE, Parent AD (1998) Anatomy of the shaken baby syndrome. Anat Rec 253:13–18
8. Kleemann WJ, Vock R, Bajanowski T et al (1997) Obduktionsfrequenz bei plötzlichen Kindstodfällen in der Bundesrepublik Deutschland in den Jahren 1985 bis 1989. Rechtsmedizin 7:72–75
9. American Academy of Pediatrics (2001) Distinguishing sudden infant death syndrome from child abuse fatalities. Pediatrics 107:437–441
10. DuChesne A, Bajanowski T, Brinkmann B (1997) Spurenarme Tötungsdelikte an Kindern. Arch Kriminol 199:21–26
11. Rognum TO, Arnestad M, Bajanowski T et al (2003) Consensus on diagnostic criteria for the exclusion of SIDS. Scand J Forensic Sci 9:62–73
12. Guerra I, Ortiz E, Portu J, Atares B, Aldamiz-Etxebarria M, De Pablos M (2001) Value of limited necropsy in HIV-positive patients. Pathol Res Pract 197(3):165–168
13. Statistisches Bundesamt Deutschland (2004) http://www.statistik-bund.de
14. Findeisen M, Vennemann M, Brinkmann B, Ortmann C, Röse I, Köpcke W, Jorch G, Bajanowski T (2003) German study on sudden infant death (GeSID): design, epidemiological and pathological profile. Int J Legal Med 118:163–169
15. Brinkmann B (1999) Harmonization of medico-legal autopsy rules. Int J Legal Med 113:1–14