

## ORIGINAL ARTICLE

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## Body and head position, covering of the head by bedding and risk of sudden infant death (SID)

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**Abstract** We examined the position of the body and head, and the covering of the head by bedding on discovery in cases of sudden infant death (SID) in Lower Saxony. Between 1.1.1986 and 31.12.1992 structured, questionnaire-based interviews were carried out with parents of 140 SID victims. Control data were taken from a population-based cross-sectional study on infant sleeping position performed by the German Health Office (BGA) in autumn 1991. Of the SID cases 86.4% were discovered in the prone position [odds ratio (OR) = 7.4, 95% confidence interval (CI) = 4.3, 12.7] and 41.4% were found with the head covered. These infants were significantly older than those where the head was uncovered ( $p < 0.001$ ) and covering of the head showed a significant association with a risk of SID (OR = 20.8; 95% CI = 11.5–37.6). Of the SID cases 27.9% were discovered in the face-down position. These infants were significantly younger than the infants who were discovered with the head in a side or supine position ( $p < 0.001$ ). This study confirms the increased risk of SID associated with the prone position and suggests that this association could be related to the development of hypoxaemia or hypercapnia. Together with other factors such as heat stress or an infection, hypoxaemia or hypercapnia could culminate in SID if the arousal from sleep and auto-resuscitation apparently fails.

**Key words** Sudden infant death syndrome · Prone position · Face-down position · Hypoxia · Death-scene investigation · Head covering

### Introduction

In recent years some potentially modifiable risk factors related to sudden infant death (SID) e.g. prone sleeping position, heat stress and smoking, have been identified (Flemming et al. 1990; Mitchell et al. 1992; Wigfield et al. 1992; Jorch et al. 1994; Irgens et al. 1995; Kleemann et al. 1996; Schlaud et al. 1996; Schellscheidt et al. 1997). In several countries the incidence of SID has been reduced by 50–70% following wide-scale public health initiatives focusing on these risk factors (Wigfield et al. 1992; Mitchell et al. 1994; Willinger et al. 1994; Irgens et al. 1995). Other risk factors may be the covering of the head and the face-down position (Templeman 1892; Abramson 1944 Werne and Garrow 1953; Adelson and Kinney 1956; Beal and Blundell 1978; Emery und Thornton 1968; Tausch und Möller 1973; Kravitz und Scherz 1978). However, there is still only scant information on the position of the head and the covering of the head by bedding in cases of SID. Our intention was therefore to investigate the position of the body and head and the covering of the head by bedding in SID cases from Lower Saxony.

### Material and methods

Details of the methods used in this study have been described and discussed elsewhere (Kleemann et al. 1996). In brief, 140 cases of SID were identified by autopsy in Lower Saxony, Germany, between 1st January 1986 and 31st December 1992 with an average age of 147 days (median 109 days). Of the SID cases 61.4% were male and 70.7% occurred in the first 6 months of life. Detailed information on the position of the body and covering of the head were obtained from the parents by structured interviews. Data from a population-based postal survey carried out by the German Federal Health Office (BGA) in Lower Saxony in the autumn of 1991 (Nolting et al. 1993) were used as a reference group ( $n = 688$ ) and combined with the interview data in a case-control design. Group differences were tested for statistical significance using  $\chi^2$ -tests or  $t$ -tests whereas adjusted odds ratios were computed by unconditional logistic regression. The alpha error was restricted to 5%.

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**Table 1** Adjusted\* odds ratios and 95% confidence intervals (95% CI) for sleeping position and SID risk

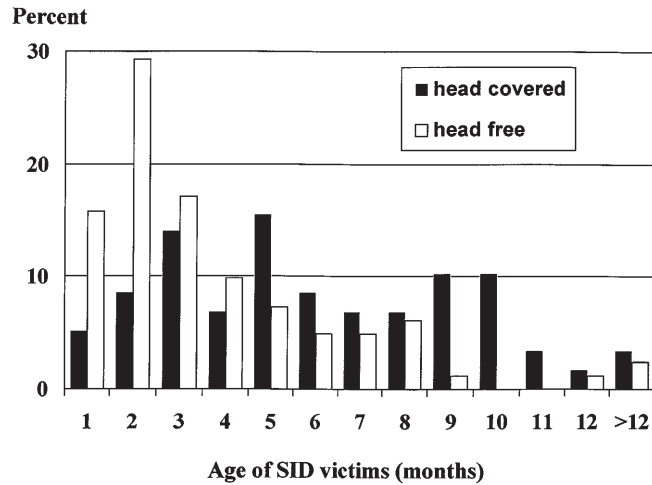
Position	SID cases		Controls		OR	95% CI
	n	%	n	%		
Side, supine	19	13.6	336	49.1	1.0	(Reference)
Prone	121	86.4	348	50.9	7.4	4.3–12.7

\* Adjusted for sex and age

**Table 2** Adjusted\* odds ratios and 95% confidence intervals (95% CI) for head covering and SID risk

	SID cases		Controls		OR	95% CI
	n	%	n	%		
Head free	78	56.5	667	97.2	1.0	(Reference)
Head covered	60	43.5	19	2.8	20.8	11.5–37.6

\* Adjusted for sex and age

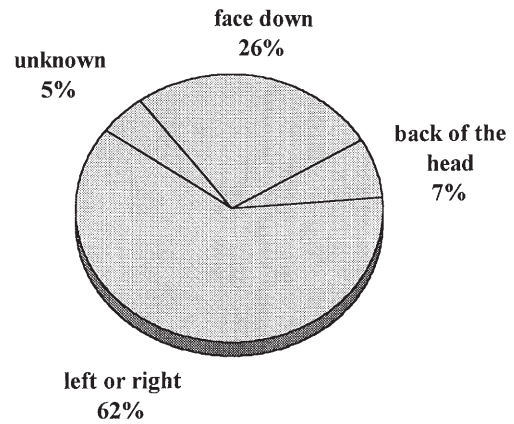


**Fig. 1** Age distribution of SID cases ( $n = 140$ ), discovered with their heads covered or uncovered ( $p < 0.001$ )

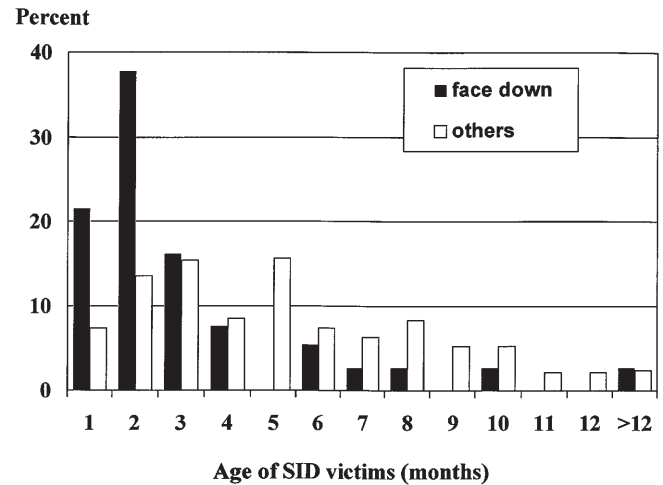
**Results**

Of the 140 SID cases 121 were discovered in the prone position (86.4%), 13 in the supine position (9.3%) and 6 on the side (4.3%). There were no significant differences between these three positions in terms of age distribution and gender. In 58.6% of all cases, the information of the attending persons on the position of the children when found could be corroborated by the pattern of the post-mortem lividity. Based on the investigations of the police, no contradictions were found to the information of the attending persons in the other cases, however the post-mortem lividity could be detected on the rear body parts only at the post-mortem examination, which was carried out some time later, as the children had been laid in the supine position in the meantime. Of the 688 controls, 49.1% were lying in the prone position and 50.9% were found in the supine or side position in the morning the questionnaire was filled in (no information was given by parents in four cases). After adjustment for age and gender, infants in the prone position were at a 7.4-fold risk of SID compared to infants in the supine position (Table 1).

In 58 cases of SID (41.4%) covering of the head was reported on discovery. The average age of these infants was 190 days, whereas the average age was 116 days in cases where the head was uncovered on discovery. The age distribution of the group found with the head under the bedding and the group where the head was uncovered



**Fig. 2** Position of the head on discovery in SID cases ( $n = 140$ )



**Fig. 3** Age distribution of infants discovered in the face-down position and of infants with their heads in the side or supine position ( $n = 140$ ;  $p < 0.05$ )

is illustrated in Fig. 1. There was a highly significant difference (two-sample  $t$  test for independent sampling  $< 0.001$ ) in the age distribution of these groups, whereas there were no significant differences in the distribution of gender. The presence of vomiting on the sleeping surface or in the air passages was significantly higher in infants with covers over the head ( $p < 0.05$ ). In our study, children who were found with the head covered were 20.8 times more likely to be at risk for SID (Table 2).

Information regarding the position of the head on discovery was available in 133 out of 140 cases. Of these

133 cases, 27.9% were found in a face-down position so that the air passages were obstructed to a large extent (Fig. 2). Infants discovered in the face-down position were on average 100 days old and therefore significantly younger than infants from the other groups ( $p < 0.05$ ) who were on average 162 days old (side position) and 196 days old (supine position; Fig. 3), respectively. Infants discovered in the face-down position were almost always less than 4 months old. There were no differences in gender or in the frequency of the presence of vomit on discovery. With infants in the face-down position there were, however, significantly fewer reports of facial sweat or sweaty clothing or bedding ( $p < 0.05$ ). Since there were no questions in the BGA questionnaires regarding the position of the head, we had no data available for risk assessment.

## Discussion

Methodological issues of this study have been extensively discussed elsewhere (Kleemann et al. 1996). In summary, it should be kept in mind that two different data sources were combined into a case-control design. However, we believe that any residual bias potentially introduced by the study design is negligible and – if present – would bias results towards the null value rather than the opposite effect.

The interviews with parents of cases and controls took place before the first major announcement in Germany in December 1991 that the prone position is a risk factor for SID (Jorch et al. 1991). Saternus (1985) demonstrated that after the prone position had been advocated since the beginning of the 1970s, 40% of infants in the Cologne area were laid to sleep in the prone position during the period 1975–1984, which is approximately the same frequency given in the BGA study.

Our study confirms the association between the prone sleeping position and SID also in Lower Saxony. On the basis of several international studies, there is scarcely any doubt that risk of SID may be associated with the prone position. This view is also supported by various studies conducted in different regions showing a simultaneous reduction in both the prevalence of the prone position and the incidence of SID (Gilbert 1994).

However, the mechanisms involved are not clearly understood. The importance of hyperthermia was recently demonstrated (Kleemann et al. 1996) and according to the data, covering of the head represents a prominent individual risk factor with an odds ratio of 20.8 (95% confidence interval 11.5–37.6). It cannot be fully ruled out that some control parents may have found their infants in the morning awake and thus in a position different from the sleeping position. However, it is unlikely that the strong association between head covering and SID found in this study is spurious, because only about 5% of control parents who had laid the infants in a prone position reported finding the child in a different position (Nolting et al. 1993). Schellscheidt et al. (1997) and Fleming et al. (1996) also found that the risk increased considerably when the head was covered.

It is possible that the prone position encourages the infants' head to become covered, because infants lying in the prone position rather than on their sides or in the supine position may tolerate the fact that the head is partially or completely covered. This presumably can be attributed to the fact that when lying on their sides or in the supine position, the bedclothes come into contact with the sensitive cheek or cheek-bone area, resulting in arousal of sleeping (Fleming et al. 1982) and consequently, infants failed to awaken when lying in the prone position. The deficiency in the awakening response may additionally be influenced by deep sleep, e.g. in the postprandial phase, a frequently detectable but non-specific infection (Kleemann et al. 1995a; Tschernig et al. 1995; Hiller et al. 1997; Bajanowski et al. 1997), the administering of drugs, particularly sedatives or anti-histamines (Kahn and Blum 1979) and fetal exposure to cigarette smoke (Schlaud et al. 1996; Schellscheidt et al. 1997). Lewis and Bosque (1995) showed that infants with fetal exposure to cigarette smoke have a deficient hypoxic awakening response.

The younger infants in particular were not covered but discovered in the face-down position, which can also lead to hypoxaemia or a disorder in temperature regulation. As there were no questions in the BGA interviews relating to the position of the head, there were no control data to make a risk assessment. However infants only very rarely seem to end up in the face-down position of their own accord. According to an investigation by Hassal and Vandenberg (1985) in which 4041 families were interviewed, only 4% of infants were discovered in a face-down position in the morning. In other investigations approximately one third of SID cases were found lying in the face-down position (Kemp et al. 1992; Ponsonby et al. 1992).

It is assumed that the face-down position causes mandible, tongue and soft palate moving posteriorly to obstruct completely or partially the oropharyngeal airway (Kravitz and Scherz 1978). During post-mortem measurements of respiratory resistance in cases of SID, air flow was insufficient whenever the infants were in the face-down position, whereas in the prone and supine position there were no differences (Emery and Thornton 1968; Schäfer et al. 1991). The degree of obstruction is dependent on the type (pillow, hard or soft surface, mattress material) and condition (dry or damp) of the sleeping surface. An extreme increase in respiratory resistance was measured, particularly in connection with damp sleeping surfaces (Emery and Thornton 1968; Emery 1990), which are frequently detected in cases of SID as a result of excessive sweating or vomiting (Kleemann et al. 1996).

In animal and mechanical model experiments, the face-down position or the presence of a soft surface caused re-breathing as a result of the mattress hollow or a wet sheet (Ryan 1991; Kemp et al. 1992; Campbell et al. 1997). A similar effect can be produced by cramped conditions in the absence of air movement (Rajs and Hammarquist 1988). With infants lying in the face-down position or under the covers, increased concentrations of CO<sub>2</sub> were recorded in the environment surrounding the infants' face, although these were not acutely life-threatening (Chiodini

and Thach 1993; Malcolm et al. 1994). In 1977 Gale et al. drew attention to the danger of an accumulation of CO<sub>2</sub> in cots. This hypothesis is supported by findings that SID cases were less likely to sleep in rooms with open windows compared to controls (Kraus et al. 1971) and that victims of sudden infant death were found more frequently on a softer surface (Carpenter and Shaddick 1965). There was an increased risk of SID only when using sheepskin as a sleeping surface if the infants were in the prone position (Mitchell 1995). There have also been reports of deaths when infants have been laid on soft surfaces such as waterbeds or sheepskins or when using pillows filled with polystyrene beads (Bass et al. 1986; Oudesluys-Murphy and van Yperen 1988; Ramanathan et al. 1988; Kemp and Thach 1991).

It must additionally be taken into account that infants will react to hypoxia or hypercapnia, which usually represents a strong respiratory stimulus, in a totally different way, in some cases with respiratory depression particularly when an infant has an infection and is too warmly clothed (Folgering and Boon 1986; Schabel and Hächl 1988; Haidmayer et al. 1993; Maskrey 1995).

The postmortem findings in SID cases are also consistent with protracted hypoxia, with a release of catecholamines and the occurrence of respiratory insufficiency during persistent circulation and metabolic acidosis. The morphological findings are more clearly pronounced in older infants and may be explained by a longer agonal period (Kleemann et al. 1995b). This strongly suggests that in most cases, SID is not a matter of a few seconds, but a protracted generalised process. It should be clearly understood that it is not possible for an autopsy to distinguish between SID and smothering, rebreathing of CO<sub>2</sub> or hyperthermia (Emery 1985; Thach 1986; Cashell 1987; Valdez-Dapena 1992; DiMaio and DiMaio 1993). Experimental findings in animals that had died from hypoxia or hyperthermia were practically identical to the findings in human SID cases (Winn 1986; Elder et al. 1996; Galland et al. 1997).

The findings of many studies suggest that the relationship of the prone sleeping position to SID could be related to preterminal hypoxia or a rebreathing of CO<sub>2</sub> in some cases, if the infants end up in a face-down position or if the head becomes covered by bedding (Beal and Blundell 1978; McGlashan 1989; Emery 1990; Jorch et al. 1991; Kemp and Thach 1991; Ryan 1991; Corbyn 1993). This view is also supported by findings from infants who died fitted to a monitoring device. The recordings also suggest that in some cases hypoxia lasting up to 2 h has occurred (Meny et al. 1994, 1996). Others important factors may be heat stress, soft sleeping surfaces, an infection and a deficiency of an awakening response.

Our data proves the need for more precise information about the sleeping environment involving the sudden death of infants and of the physiology of the arousal process. During the planning of this study, we were unaware of the significance of many factors such as the condition and firmness of the sleeping surface, the type of bedding and the clothing and this information was there-

fore not recorded. Further urgent investigation is needed to identify possible risk factors. The reduction in the number of cases involving sudden infant death in recent years has shown that it is possible to take successful preventive measures without final clarification of the pathogenesis.

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