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Hyperthermia in sudden infant death

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Abstract To determine whether preterminal hyperthermia is significantly associated with sudden infant death (SID), 140 structured interviews with parents of SID victims were compared with questionnaires filled in by a control group of parents living in the same area. All SID autopsies were performed between 1986 and 1992 at the Institute of Legal Medicine of Hannover Medical School according to the same protocol. Signs of profuse sweating (i.e. moist head, damp clothing or bedding) were present at the scene of death in 35.7% of cases. SID victims with signs of profuse sweating were more frequently found under their bedding ($p < 0.001$), were older (178 vs. 130 days) and the time period between when they were last seen alive and when they were found dead was longer (6.5 vs. 4.5 hours $p < 0.01$) compared to cases without sweating. Sweat on the head [odds ratio (OR) = 1.9; 95% confidence interval (CI) = 1.0, 3.6], and sweaty clothing and bedding (OR = 17.9; 95% CI = 8.7; 37.1) showed a significant association with the risk for SID. The pathophysiological basis for hyperthermia in SID remains to be determined. Hyperthermia could result from infection, overinsulation from excessive clothing with high environmental temperatures, covering of the infant's head or immature central thermoregulatory centres. The influence on the fatal outcome and the role in the pathogenesis of these deaths requires further research.

Key words SID · SIDS · Hyperthermia · Swaddling · Death scene investigation

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Introduction

The role of hyperthermia in sudden infant death (SID) has been discussed for a long time. Many authors have called attention to the preterminal sweating of infants during sleep (Wilske 1984; Nelson et al. 1989) and in 1983 Beal reported preterminal nocturnal sweating in 38% of SID cases. Profuse sweating during sleep may therefore be regarded as an indication of an increased risk of SID (Wilske 1984; Kahn et al. 1990). To examine the frequency of preterminal hyperthermia, we interviewed 140 parents of SID infants and compared their responses with those of a control group of parents (non-SID infants) in Lower Saxony.

Materials and methods

Due to increased criticism of the term SIDS (Huber 1993; Gilbert-Barness 1993), we have chosen to use the term SID. All infants included in this study died in Lower Saxony between 1986 and 1992 and were autopsied according to the same protocol at the Institute for Legal Medicine of Hannover Medical School. Histological, immunological and microbiological studies were also performed. Mild infections of the upper respiratory tract, middle ear or positive bacteriological or virological findings without morphological correlations were not considered to have been a cause of death.

As we intended to study age-related influences, our study included infants between 7 and 730 days old. Many studies on sudden infant death only included infants up to the age of 1 year. However, 2–5% of cases of sudden infant death occur after the first year of life (Bain and Bartholomew 1985; Goldberg et al. 1986) and Beckwith's (1970) definition of SIDS does not include any age limitation.

In SID cases, structured, questionnaire-based interviews were carried out with the bereaved parents. These interviews collected detailed information about the pregnancy, birth, postnatal development and the scene and circumstances of infant death. They were carried out by physicians and lasted 2–3 hours.

The control group consisted of participants in a population-based, cross-sectional study on infant sleeping position that was performed by the German Federal Health Office (BGA) in three German states in the autumn of 1991. Questionnaires were mailed to a random sample of 5293 parents (n = 3330, 62.9% response), whose infants were up to one year old, to obtain data on the sleeping position, sleeping pattern and home environment on the night

before the questionnaire was filled in (Nolting et al. 1993). In Lower Saxony, 688 parents (74.4 % response) returned completed questionnaires to the study center. Data from the structured interviews were combined with data from the BGA questionnaires into a case-control design. The 140 interviews of SID parents in Lower Saxony were defined as "cases" and the 688 questionnnaires of parents of infants in Lower Saxony were defined as "controls". Chi-square tests, t-tests, and analyses of variance were calculated using the Statistical Package for the Social Sciences (SPSS) for Windows Release 6 with a significance level of 0.05. Adjusted odds ratios and 95% confidence intervals were computed using the unconditional logistic regression procedure of SPSS.

Results

The youngest infant in the SID cases was 19 days old. A total of 6 infants (4.3%) were older than one year (369, 373, 400, 481, 504, 581 days old) and two of them had been born prematurely at 32 weeks gestation. The average age of all SID cases was 147 days (Median 109 days). Of the sudden infant death cases, 50% occurred in the second to fourth month of life, 70.7% in the first six months and 61.4% were males. In 50 cases (35.7%) signs of sweating (i.e. moist head, damp clothing or bedding) were reported. In the others it was reported that the infants were warm or cold and dry, and in three cases infants were reported to have felt hot; however, sweating was not noted (Table 1). For further comparison, SID infants with signs of sweating (n = 50) were assigned to one group and compared with a second group of SID infants without signs of hyperthermia. There were no significant differences between the groups with regard to gender. However, infants with signs of sweating had been found more frequently under their covers ($p < 0.001$), were older (178 days; 95% CI 153-203 vs. 130 days; 95% CI 107-154) and the time period between last being seen alive and being found dead was significantly longer (6.5 h vs. 4.5 h; $p < 0.01$). In our case control analyses relative risks associated with signs of profuse sweating were statistically significant (wet head; OR = 1.9; 95% CI 1.0, 3.6; wet clothing and bedding; OR = 17.9; 95% CI 8.7, 37.1; adjusted for age and sex Table 2). This shows a clear dose-response relationship for the factor "hyperthermia".

Table 1 Conditions of SID infants at the site of death (n = 140)

	n	%
Clothing and bedding soaked with sweat	35	25.0
Sweaty face, dry clothing	15	10.7
Infant was hot	3	2.1
Infant was warm and dry	47	33.6
Infant was cold and dry	39	27.9
Unknown	1	0.7
Total	140	100

Table 2 Adjusted* odds ratios (OR) and 95% confidence intervals (95% CI) for an association of sudden infant death and the presence of signs of profuse sweating (n = 139)

	SID		Controls		OR	95% CI
	n	%	*n*	%		
No signs of sweating	89	64.0	617	90	1.0	Reference
Sweaty head	15	10.8	57	8,3	1.9	1.0, 3.6
Clothing and bedding soaked with sweat	35	25.2	12	1,7	17.9	8.7, 37.1

* adjusted for age and sex

Discussion

Data used for this study were obtained by combining data from two different studies into a case-control design. This may introduce bias if cases and controls were sampled from different source populations. In the BGA study, which served as the source for the control data, a random sample of the population was taken from the same regions as the SID cases. Because the BGA questionnaire was sent out during the same time as the observation period of the SID study, we can assume that the populations studied were comparable. We therefore believe that bias due to different populations is negligible.

Parents of SID infants were interviewed while those of the control group responded to a written questionnaire. This could also have influenced the study by information bias. The interviews were carried out according to a structured documentation sheet and then compared with the BGA questionnaires. Thus, both studies included the same questions, and responses were documented in the same categories. In both SID cases and controls, the questions focused on a recent event i.e., the circumstances on the morning of the day the questionnaire was being filled in.

Finally, there is a basic difference between interviews and written questionnaires. In particular there is a potential for recall bias which occurs in case-control studies and is caused by an event-induced intensification of recalling details of an event. In this study, potential recall bias of "cases" may have been compensated by the fact that the "controls" spent more time answering the questions. This is because the written questionnaires were sent to the "controls" and remained in their possession longer. Any recall bias, if it occurred, may thus be more likely to have biased the results towards the null rather than the opposite effect.

In the absence of better data, we believe that our data, compiled from different sources, are adequate to estimate the risk of infants with signs of profuse sweating. However, when interpreting these results, the limitations of this approach should kept in mind.

Signs of preterminal hyperthermia were present in 35.7% of the SID cases. In the controls only 10% of infants were found with signs of sweating in the morning. Cooling occurs rapidly in infants because of their high surface to mass ratio. Therefore the actual number of SID infants with prefinal hyperthermia may be even higher than that found in this study. This is why even if signs of profuse sweating were present in infants who died shortly after being put to bed, no temperature elevation or signs of sweating would be noted the next morning. This argu-

ment is supported by studies done in the former GDR, where taking of rectal temperatures at the scene of death was mandatory and in which 86% of cases were found to have increased rectal temperatures, some greater than 40° C (Pfeifer 1980).

We would like to stress that preterminal hyperthermia as the cause of death cannot be demonstrated by autopsy because there are no specific morphological changes that occur in hyperthermia (Variend and Sunderland 1984). The diagnosis of preterminal hyperthermia is only possible after making an extensive study of the case history as well as paying attention to details such as measurement of ambient temperature. This stresses the importance of thorough documentation of conditions at the scene of death.

One explanation for hyperthermia in SID could be the presence of infections (Althoff 1980), even if these infections may be significant only in combination with other factors (Kleemann et al. 1995a; Tschernig et al. 1995). Gilbert et al. (1992) showed that viral infections combined with heavy clothing placed infants at an increased risk of SID but light clothing was not associated with increased risk. Mothers with a lower educational level tend to clothe their infants more heavily and to heat rooms more (Eiser et al. 1985). It has also been shown that the risk of sudden infant death increased when the heating was left on at night (Fleming et al. 1990). Parents tend to dress their infants more heavily and use thicker bedding when infants are sick and when outside temperatures drop (Wailoo et al. 1989; Jones et al. 1994). Rajs and Hammarquist (1988) reported that infants who died at home in a cart or cradle were dressed very warmly. High outside temperatures have also been shown to increase the risk of sudden infant death (Nelson et al. 1989).

In addition to factors such as infection, warm clothing and elevated outside temperatures, body position can also influence temperature regulation. It is now widely accepted that the prone position increases the risk of sudden death (Mitchell et al. 1992; Jorch 1994). The prone position and hyperthermia appear to be two independent risk factors (Ponsonby et al. 1992). According to our own unpublished data, 26% of infants found in the prone position also had their faces down. Lying face down, infants cannot dissipate heat well because the face is the major site for involuntary water and heat loss in infants (Anderson et al. 1990; Fleming et al. 1992). This potential mechanism, however, does not appear to have played a major role in our study because most of the younger infants (average age 130 days), who had no signs of preterminal hyperthermia, were found face down. As reported by Gilbert et al. (1992), we also found a relationship between age and signs of preterminal hyperthermia in sudden infant death. Infants who were found with signs of profuse sweating were on average 48 days older and were often found under their covers. Furthermore, the time period between when these infants were last seen alive and when they were found dead, was significantly longer in infants with signs of sweating. Similarly, in rabbits and pigs it was found that lethal hyperthermia only occurred after being under a feather pillow for some hours (Tausch and Möller 1973). These animals all had thymic, epicardial and pleural petechiae – a finding which is also present in sudden infant death and suffocation (Winn 1986; Kleemann et al. 1995b).

It is not known what role, if any, hyperthermia plays in the pathophysiology of sudden infant death. We do not agree with Wilske (1984) that hyperthermia is only a sign of a disturbance in the central regulation. Whether it is caused by infection or thick covering or clothing requires further research. Hyperthermia, increased metabolic rate and increased oxygen demand all result in an increase in the respiratory rate. A lethal outcome is possible if there is additional hypoxia or hypercapnia, which would have otherwise not been lethal on it's own. It is also possible that first there is protracted hypoxia, and hyperthermia occurs only preterminally (Gaedecke 1978).

Our study demonstrates that hyperthermia is significantly associated with sudden infant death, even though it's role in the pathophysiology of these deaths has not yet been elucidated. Parents of infants should therefore be educated about the possible dangers of high ambient temperatures and thick clothing of infants, particularly when their infants are suffering from an infection.

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