

Post-Neonatal Sudden Unexplained Death in a California Community

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To gain further insight into the problem of infant sudden death, a study was undertaken to investigate a complete series of cases of infant sudden unexplained death that occurred during a seven-year period in Sacramento County. Needed information was abstracted from autopsy records, Medical Examiner's records and death certificates. The average death rate for the seven-year period was 1.7 for 1,000 live births. Average age at time of death was 2.8 months. There were no records of sudden death among infants over the age of eight months.

Higher than average death rates were observed within many of the low socioeconomic areas of Sacramento County. Also, sudden unexplained deaths appeared to occur more frequently in the winter months than in the spring, summer or fall. In over half the cases the infants had a cold, the sniffles, or other respiratory tract congestion within two weeks of the date of death, which seems to support the oft-quoted contention concerning the possibility of nasal obstruction which could initiate the fatal apnea. An additional notable finding was the very frequent occurrence of petechial hemorrhage in the thymus, heart, and lung tissues.

The unique age distribution of these deaths in combination with the high frequency of low socioeconomic groups and the frequency of minor respiratory ailment would suggest approaches that can be taken to identify infants at high risk and thus initiate effective community health programs for prevention.

ALTHOUGH THE PHENOMENON of sudden unexplained death in infancy (crib death) has been recognized for many decades and studied extensively,¹⁻¹² its magnitude is not fully appreciated. In 1968 the incidence in California of this tragic cause of death in the post-neonatal period (28 days to one year) was 1.55 per 1,000 live births.¹

A recent communication described certain factors that were found to be related to crib death.¹ The most consistent of these factors were age (a peak occurrence from one to four months of age), race (higher death rates for black and American Indian than for white or Oriental infants), birthweight (high rates for infants of low birthweight) and shortened gestational age. Other factors included low income-producing occupation of the father, younger age of mother and abbreviated or total lack of prenatal care. These findings were based, however, on information obtained from birth certificates in a cohort of live births during one year. To gain more insight into this tragic phenomenon, a study was undertaken to investigate a complete series of cases of infant sudden and unexplained death that had occurred during the period of 1964 to 1970 in Sacramento County, California.

Methods and Materials

California law requires that county medical examiners perform autopsy in all cases of sudden, unexpected or accidental deaths for the purpose of determining the exact cause of death. Information on all infants who die suddenly or unexpectedly in Sacramento County is routinely recorded and kept in the county coroner's office. Autopsy protocols for all cases of infant sudden deaths that had occurred during the years 1964 to 1970 were retrieved and reviewed; all pertinent data from these records were abstracted on a pre-designed form. Pathological examinations in all cases included in this study had been performed by one of us (P. R.). To insure complete case ascertainment for the period under study, death certificates for all infants who died in Sacramento County during these years were retrieved from the files of the county and state health departments. The review of these death certificates included a systematic search for any indications of sudden

unexplained death recorded on the death certificate either as "underlying cause of death," "contributing cause of death" or "consequence of death." Specific attention was given to such epithets as "crib death," "cot death," "cause of death unknown," and "sudden or unexplained death." A list of sudden unexpected infant deaths obtained from the search of death certificates was then matched with the records of the Sacramento County coroner's office. The main criterion used for inclusion of a case in this study was that sudden and unexpected death had occurred when the infant had been in good health or his terminal illness was judged to be so mild that possibility of a fatal outcome was not anticipated. In other words, the death had to be sudden and unexplained to qualify for inclusion in the study.

Our extensive and systematic search yielded a total of 128 such deaths which had occurred in Sacramento County during the years 1964-1970. In nine of these cases the babies were not residents of Sacramento County and therefore were not considered in some of the subsequent analysis of data. To avoid problems associated with neonatal deaths (for example, birth injury and congenital malformation), the age of infants selected for the study was limited to the post-neonatal period (28 days to one year). Information derived from the autopsy protocols and death certificates included data on age, sex, race, date, time and place of death, the general circumstances surrounding the death, and autopsy information on the gross anatomic and microscopic findings as well as results of other standard laboratory tests. To determine incidence rates, information on all live births during this seven-year period was also obtained from the files of the Sacramento County and State of California health departments. The seven-year aggregate of cases was then used as the basis for calculating rates and reporting the epidemiologic features of sudden unexplained death in Sacramento County.

Results

Epidemiology

As can be seen from the data presented in Table 1, the incidence of sudden death per 1,000 live births varied during the seven-year period under study. The 1970 death rate of 0.9 per 1,000 live births is the lowest recorded during this period while rates for 1964, 1966, and 1968 were the highest. A secular trend in the rate of sudden

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TABLE 1.—Incidence Rates of Post-Neonatal Sudden Unexplained Death, Sacramento County, California, 1964-1970

Calendar Year	No. of Live Births	No. of Sudden Deaths	Rate per 1,000 Live Births
1964	11,557	23	2.0
1965	10,554	13	1.2
1966	9,997	20	2.0
1967	9,857	18	1.8
1968	9,673	21	2.2
1969	9,938	15	1.5
1970	10,155	9	0.9
ALL YEARS	71,731	119	1.7

TABLE 2.—Rates of Sudden Unexplained Deaths, According to Census Tract Areas, Sacramento County, California, 1964-1970

Areas	No. of Births	No. of Deaths	Rate per 1,000 Live Births
Washington	3,889	9	2.3
Oak Park-Glen Elder	5,807	17	2.9
Del Paso-Robla	10,327	27	2.6
Cosumnes-Delta	1,841	2	1.1
Remainder of County	49,867	64	1.3
COUNTY AS A WHOLE	71,731	119	1.7

TABLE 3.—Distribution of Sudden Unexplained Deaths, According to Month of Death, Sacramento County, California, 1964-1970

Month	No. of Deaths	Percent Deaths
January	23	18.0
February	14	10.9
March	16	12.5
April	11	8.6
May	10	7.8
June	11	8.6
July	7	5.5
August	9	7.0
September	5	3.9
October	7	5.5
November	4	3.1
December	11	8.6
ALL MONTHS	128	100.0

Differences by month of the year are statistically significant: $\chi^2=28.19$, $p<.001$

death was not observed. The average death rate for the entire seven-year period (1.7 per 1,000 live births) is very close to the rate we had reported previously for the 1968 California live birth cohort as a whole (1.55 per 1,000 live births).¹

The average age of infants at death for all cases in this series was 2.8 months. Almost 83 percent of all sudden deaths in this series of cases occurred before the age of six months. There were no sudden deaths between the ages of eight months and one year. Almost one-third (32.8 percent) of the sudden deaths occurred between the first

and second month of age and over one-half occurred before the age of three months. The proportionate distribution of deaths by age at time of death was found to be consistent with findings of other epidemiologic studies of sudden unexplained death reported for the State of California as a whole, and other areas in the United States, Canada, and Western Europe.¹⁻¹⁴

As has been found in other studies,^{1-5,9,10} the incidence of sudden death was greater in male than in female infants (58.6 percent and 41.4 percent). However, when compared with the expected frequency based on the distribution of live births by sex, the difference in frequency of sudden death between male and female infants was not statistically significant ($p>.05$).

The rate of sudden infant death among white infants was 1.5 per 1,000 live births and among black infants it was about twice as high (3.4 per 1,000 live births). Among Oriental infants the rate of sudden death was somewhat lower than in other racial groups (1.1 per 1,000 live births).

Census tracts for Sacramento County, as defined by the U.S. Bureau of the Census, were grouped into five major areas. These areas included (1) *Washington* area (the central portion of the City of Sacramento) with 25 percent black and Mexican-American and a median annual family income of \$7,500; (2) *Oak Park-Glen Elder* area with more than 30 percent black and 20 percent Mexican-American and a median family income of \$6,500; (3) *Del Paso-Robla* area with 20 percent black and a median family income of \$7,000; (4) *Cosumnes-Delta* area with 35 percent Mexican-American and a median family income of \$9,500; and (5) the remainder of the county with a median family income of \$13,500 and mostly white population. Death rates, by above census tract groups, are presented in Table 2. As can be seen, rates in the *Oak Park-Glen Elder*, *Del Paso-Robla*, and the *Washington* areas are noticeably in excess of the overall rate of 1.7 per 1,000 live births for the county as a whole. On the other hand, the rate in the remainder of the county is very low. The low rate found in the *Cosumnes-Delta* area is not significant because of small numbers ($N=2$).

Temporal Distribution

Season. The distribution of sudden unexplained deaths according to month of death for the seven-year period of study (Table 3) indicates a peak frequency during the month of January. The fre-

quency of sudden death appears to be higher throughout the winter and early spring months than it is during summer and fall. The observed difference in occurrence of sudden death according to month of the year is statistically significant ($p < .001$) when compared with the number of deaths expected on the basis of a null hypothesis of equal frequency throughout the year.

Day of the Week. The proportionate distribution of deaths by days of the week (Sunday through Saturday) showed no significant differences from the null hypothesis of equal distribution throughout the week ($p > .50$).

Time of Day. For most of the cases studied, time of death was at best only an approximation based on information obtained by the investigating coroner's deputy from the parent or guardian. Where not precisely known, time of death was estimated at the midpoint from the time the infant was last seen alive and the time found dead. The distribution of deaths by hour of death recorded on the autopsy protocol were 23.6 percent for midnight to 6 a.m., 53.1 percent for 6 a.m. to noon, 14.9 percent for noon to 6 p.m.; and 8.6 percent for 6 p.m. to midnight. This distribution by time of the day is significantly different from a null hypothesis of equal frequencies in six-hour intervals throughout the day ($p < .001$).

Marital Status of the Parents

Almost one-third (32.8 percent) of all deaths occurred in families in which either the parents were not the natural parents of the infant or where one parent was separated, divorced, or otherwise not living with the other. There are no available data for comparison to determine the significance of this observation.

Medical History

More than half of all the infants (56.3 percent) were reported to have had either a cold, sniffles, respiratory congestion or some form of respiratory ailment within two weeks of the date of death. Two were recorded to have an episode of asthma, diarrhea, and elevated temperature within two weeks before death. At the time of the autopsy no attempt was made to isolate or identify microorganisms.

Sixty-four percent of the infants were reported to have had an episode of sickness or illness some time before the date of death. These were mostly mild colds or sniffles. Over three-fourths (78.9 percent) of the infants had been seen by a physi-

cian at least once since birth. These visits were for purposes of check-ups or in conjunction with a minor illness. Fourteen infants had been in hospital at some time since birth for specific illnesses; the diagnoses included asthma, diarrhea, and anemia.

Sleeping Conditions

In 51.6 percent of cases the infants were found dead in the crib, 8.6 percent were reported to have died in bed, and 4.7 percent on a sofa or couch. For about 20 percent of all cases, the location was some other place such as a mattress on the floor. The type of room in which the infant was found dead was not routinely recorded on the autopsy protocol. Also, for 50 percent of all cases the position of the infant when found dead was not reported; but among those in whom this information was available, one half were found dead lying on their stomachs.

Pathology

Gross Findings

Most of the infants examined appeared to be reasonably well nourished. A few had a diaper rash and one infant was noted to have a minor bruise on his body. There was no evidence to suggest neglect or ill treatment in any of the cases. A frothy blood-tinged fluid was observed at the nose or mouth in 36.7 percent of all the bodies examined.

Thymus. The thymus was frequently found to be large, perhaps a normal finding for early infancy. Petechial hemorrhages were observed in 30.3 percent of all infants.

Heart. In all instances the heart was normal, with no pathological finding except epicardial petechiae, which were observed in 46.7 percent of all cases studied.

Lungs. Petechial hemorrhages or minimal edema or both were noted in all but 8.6 percent of the cases.

Brain. Minimal petechial hemorrhages scattered throughout the surface of the brain tissue were noted in 5 percent of cases.

Other organs. No gross anatomic or pathologic lesions were found in the liver, spleen, kidney, or digestive tract.

Microscopic Findings

Thymus. The tissues of the thymus were seen to be essentially normal in 54.4 percent of cases. Petechial hemorrhages alone or in combination

with hyperemia were the major abnormal findings in 42.2 percent.

Heart. The tissues of the heart were essentially normal in 54.4 percent of cases. The single most frequent abnormality was petechial hemorrhage (12.7 percent).

Lungs. Detectible edema of the lungs was noted in 77.7 percent of cases. Focal atelectasis was found in over one-half of the cases.

Brain. The most frequent abnormal finding of the brain was petechial hemorrhage, seen in 26.5 percent.

Other Tissues. The most frequent remarkable finding for other organs examined was petechial hemorrhage. The proportion of infants with these lesions in the various other organs examined were: spleen, 22.2 percent; kidney, 12.2 percent. Inflammation of the trachea or larynx was noted in 19.6 percent. All other organ systems were essentially unremarkable.

Routine laboratory examination of the blood for barbiturates, blood alcohol or carbon monoxide yielded negative results in all cases examined.

Discussion

The findings of this study confirm, in general, those of other studies conducted in large metropolitan areas³⁻⁴ and the State of California as a whole.¹ The seven-year average death rate in Sacramento County, however, was lower than that reported in most other studies,^{2-4,6,9} except Minnesota⁵ and California.¹ The age distribution of infants at the time of death was similar to that in almost all other studies. Our finding of a high rate of infant sudden death among black infants confirms similar findings reported elsewhere.²⁻⁴ That almost one-third of all deaths occurred within families where only one of the natural parents was living in the house might be interpreted to suggest the possibility of psycho-social stress manifested in single-parent families as a risk factor.

That 56 percent of the infants in this series were determined to have had a recent episode of a cold or some form of respiratory ailment appears to suggest the possibility that nasal obstruction due to a mild infection could initiate fatal apnea, as Shaw¹³ suggested. Although on gross inspection

there was no indication of gross obstruction of the trachea, larynx or nasal atria in any of the infants examined, microscopic studies showed that 42.2 percent of these babies had evidence of tissue inflammation of these organs.

A notable finding in this study was the very frequent occurrence of petechial hemorrhage in the thymus, heart and lungs. Petechiae are reported as an almost distinctive feature of sudden unexplained death,¹⁴⁻¹⁷ but it should be emphasized that in 9 percent of our cases no such petechial hemorrhage was noted at autopsy.

Finally, it should be borne in mind that although etiologically this condition is poorly understood, it is possible to design community preventive programs aimed at identifying infants who might be at high risk and thus initiate effective community health programs to prevent this tragedy.

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