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ORIGINAL ARTICLE

Petechial bleedings in sudden infant death

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Abstract The autopsy reports of 484 cases of deceased infants (201 females, 283 males) were analysed retrospectively for the existence of external and internal petechial bleedings (PET). The cases were divided into five groups on the basis of the cause of death (sudden infant death syndrome, sepsis, airway infections, asphyxia and trauma). Internal PET (pleural, pericardial, epicardial, thymic and peritoneal) were observed in each group with a lower prevalence in cases of trauma. The highest prevalence of external (cutaneous and conjunctival) PET was detected in cases of asphyxia (38% and 31%, respectively). However, even if with low prevalence, such bleedings were detected in every group. Factors like sex, age, cardiopulmonary resuscitation and its duration did not influence the presence of PET. The detection of external PET at autopsy is a suspicious finding that suggests asphyxia. Because of the possible natural origin of these bleedings, the medicolegal investigation has to be as complete as possible and has to include histology as mandatory.

Keywords Sudden infant death · Petechial bleedings · Suffocation

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> "… en 1847, il a noté en quelques lignes «la présence chez les enfants qui ont succombé par suite de l´ occlusion incompléte ou compléte des voies aériennes, d´ecchymoses ponctuées disséminées sous la plevre pulmonaire»."
>
> Ambroise Tardieu [34]

Introduction

Petechial bleedings (PET) in the thymus and into the serous surfaces of the thoracic organs and walls can be detected in

sudden infant death syndrome (SIDS) cases as a typical finding [9, 20, 23].

In contrast, the existence of external PET is not characteristic for SIDS. Yet, if it does occur, it should raise suspicion of suffocation death [10, 16, 25, 29].

The pathogenesis of PET is heterogeneous. All authors agree with the mechanical origin, i.e. rupture of vessels due to increased intravascular pressure [18]. But there also exist several predisposing or modifying factors such as age, gender, constitution and heart weight [28]. Capillaries can become more susceptible to mechanical forces if they are damaged by hypoxic, immunologic or toxic processes [21, 26, 27].

Among the forces that increase intravascular pressure, there is firstly the venous congestion induced by acute heart failure, strangulation, mechanism of Valsalva (e.g. labours, defecation, coughing fits), thorax compression, etc. Certain malfunctions have been ascribed an additional force, i.e. a steep increase of the arterial pressure which occurs under conditions such as expressed coughing fits (pertussis, aspiration) and acute asphyxiation [13, 15]. Systolic peak pressures higher than 300 mmHg have been observed. These peak pressures continue into the capillaries. Finally, a retrograde blood shift can occur, especially in the case of traumatic asphyxia [12, 31]. A combination of the aforementioned forces might exist in many individual cases.

A topographic factor can also play an important role: the increased pressure inside the vessels predisposes a higher risk of rupture, especially in the conjunctiva and the eyelids where the loose connective tissue cannot give a valid external support to the vessel wall [26].

The aim of our study was to explore the prevalence of external and internal PET in cases of SIDS. Furthermore, we aimed at investigating the possible influence of cardiopulmonary resuscitation (CPR) and infections of the respiratory system.

Materials and methods

The autopsy reports of 484 cases of deceased infants (201 females, 283 males) were analysed for external and internal PET. Data were obtained from documents collected during the multi-centre German study on Sudden Infant Death Syndrome (GeSID) during the period from 1998 until 2001 [5, 19]. The cases were classified according to the causes of death: 404 cases of SIDS (162 females, 242 males, mean age 3.9 months), 80 cases of explained death (42 females, 38 males, mean age 4.7 months). The SIDS cases were further divided into three subgroups mainly defined on the basis of the pathological findings as described elsewhere [5]. Briefly, the categorisation can be summarised as follows: category 1 if no pathological findings can be diagnosed, category 2 in cases of minor pathological findings and category 3 in cases with more severe findings, however not explaining the cause of death. The non-SIDS group included 24 cases of sepsis, 24 fatal respiratory infections, 13 asphyxial deaths and 19 traumatic deaths (Table 1).

Information about the presence of PET into the conjunctivae and the skin (external PET) was indicated by the pathologists in a questionnaire after the autopsy in all cases. Moreover, PET into the parietal and visceral pleura, pericardium, epicardium, thymus, parietal and visceral peritoneum were registered. PET were categorised into four grades (nil, few, moderate and many). Information about the position of the body at discovery, CPR and its duration and post-mortem interval were also available. Fisher's exact test was performed for statistical analysis [3].

Results

We could not demonstrate any difference in the prevalence or distribution of the PET in correlation to gender and age. In 19 (4.8%) cases of SIDS, we observed PET into the conjunctivae, while their prevalence in the controls was 4–31%, with the maximum in cases of asphyxia (p=0.03; Table 2).

In the SIDS group, cutaneous PET were registered in 32 cases (8.7%). The bleedings were located in the face (frontal region, eyelids) and the neck, but were also found in locations such as the shoulder and upper chest. Furthermore, there is a good correlation between PET of the skin and in the conjunctivae. In the control groups, they were detected in 8–38%, the maximum in cases of asphyxia (p=0.03; Table 2).

Table 1 Characteristics of the studied population

SIDS cases are classified on the basis of their pathological findings as described elsewhere [5]

Cat. 1 no pathological findings from autopsy and additional investigations, *Cat. 2* minor pathological findings, *Cat. 3* severe findings

Group	Number	Sex	Mean age (months)	SD
SIDS cat. 1	33	8 females, 25 males	3.9	2.4
SIDS cat. 2	278	117 females, 161 males	3.7	2.5
SIDS cat. 3	93	37 females, 56 males	4.2	3.1
Sepsis	24	10 females, 14 males	4.4	3.6
Airway infection	24	15 females, 9 males	3.2	2.9
Asphyxia	13	6 females, 9 males	7.1	5.9
Trauma	19	7 females, 12 males	4.2	5.6

Table 2 Prevalence and distribution of the petechial haemorrhages in the studied groups

Group	Skin	Conjunctiva	Right par. pleura	Left par. pleura	Right visc. pleura	Left visc. pleura	Pericardium	Epicardium	Thymus	Par. peritoneum	Visc. peritoneum
SIDS category 1 (n=33)	3% (1)	3% (1)	12% (4)	9% (3)	75% (24)	73% (24)	25% (8)	67% (22)	80% (24)	19% (6)	17% (5)
SIDS category 2 (n=278)	9% (24)	6% (15)	13% (34)	12% (33)	68% (188)	67% (186)	18% (50)	60% (166)	74% (194)	9% (24)	10% (27)
SIDS category 3 (n=93)	8% (7)	3% (3)	8% (7)	9% (8)	51% (47)	52% (48)	16% (15)	54% (49)	70% (60)	8% (7)	9% (8)
Sepsis (n=24)	8% (2)	4% (1)	17% (4)	17% (4)	62% (15)[a]	58% (14)	4% (1)	42% (10)[a]	64% (14)[a]	13% (3)	17% (4)
Airways infection (n=24)	10% (2)	4% (1)	17% (4)	17% (4)	73% (17)	70% (16)	4% (1)	48% (11)	61% (14)[a]	9% (2)	9% (2)
Asphyxia (n=13)	38% (5)[a]	31% (4)[a]	8% (1)	8% (1)	46% (6)	46% (6)	8% (1)	46% (6)	67% (8)	15% (2)	15% (2)
Trauma (n=19)	11% (2)	6% (1)	5% (1)	5% (1)	42% (8)[a]	42% (8)[a]	5% (1)	32% (6)[a]	32% (6)[a]	5% (1)	5% (1)

In parentheses, the number of observed cases. Percentage was calculated as number of observed cases/total number of cases in which the finding was described. In rare cases, missing data occurred

[a] Statistically significant

PET into intrathoracic structures occurred in up to 80% in SIDS and up to 73% in the remaining cases; the lower prevalence in the thymus and epicardium among the traumatic deaths is statistically significant (p=0.001 and 0.03, respectively).

A CPR was performed in 39% of the SIDS cases. In this subgroup, neither the prevalence nor the distribution of PET was influenced by CPR. In 24 cases, precise information about the duration of the CPR was available (Table 3): the mean duration was 45 min (minimal duration, 10 min; maximal duration, 90 min); no correlation between CPR and extent of the bleedings was observed.

Discussion

The occurrence of petechial haemorrhages into the skin and the serous membranes interests the forensic pathologists since they were firstly reported in a case of asphyxia by Henri Bayard in 1874 [8]. Bayard's report was later correctly cited by Ambroise Tardieu in his famous article on asphyxia [34]. For the tricks of fortune, Tardieu's name was immortalised by this description [14, 25, 36], while Bayard was forgotten [35].

Even if the original value attributed to this finding by the first observers, namely, asphyxia specificity, has been belittled [30, 39], PET remain a sign whose detection at autopsy requires a careful evaluation. This is especially true for external PET detected in infants [4].

The present study shows that PET can be found in serous surfaces in cases of SIDS as well as in other groups. The lower prevalence in traumatic deaths may reflect a short period of agony and thus a lower tendency in this group to develop terminal hypoxic vascular damage, especially in cases with consistent loss of blood [1].

Even if the higher prevalence of cutaneous PET in cases of asphyxia was statistically significant, it was low compared to other studies (e.g. [10, 23]). Actually, the composition of our group is quite heterogeneous (Table 4): approximately 30% of our cases were aspirations where cutaneous PET did not occur. Aspirations stimulate defence reactions such as coughing fits leading to increased intrathoracic pressure as well as arterial high pressure waves thus facilitating the formation of PET. However, aspiration is often an agonic phenomenon [7] with weaker defence reactions: in similar cases, a lower incidence of cutaneous PET is possible. If the aspiration cases are not taken into account, the prevalence of skin and mucosal PET in our group rises to 56% and 44%, respectively: these percentages seem more realistic. Moreover, in our asphyxia group, there were no cases of compression of the neck and/or the thorax, typically correlating with the development of external PET. Therefore, we cannot compare our results to

Table 3 In the present study, CPR did not influence the presence of PET

ID	Sex	Age (in months)	CPR duration (in minutes)	External PET	Internal PET
1	M	5.5	10	No	Visceral pleura, epicardium, thymus
2	M	3	15	No	No
3	F	2	20	No	Epicardium, thymus
4	M	2.5	20	No	Visceral pleura
5	M	9	20	No	Visceral pleura, thymus
6	M	2.5	30	No	Visceral pleura, epicardium, thymus
7	M	3	30	No	Visceral pleura, pericardium, thymus
8	M	8	30	No	Pericardium, epicardium, thymus
9	M	6	35	No	No
10	F	1	40	No	Pericardium, epicardium
11	F	0.5	45	Single PET at the left temporal region	Visceral pleura, thymus
12	F	2	45	No	Parietal and visceral pleura, pericardium, epicardium, thymus
13	M	2.5	45	No	No
14	F	7	45	No	Visceral pleura, pericardium, thymus
15	F	5.5	45	No	Epicardium
16	F	2	55	No	Visceral pleura, epicardium
17	F	2	60	No	Visceral pleura, epicardium, thymus
18	F	5	60	No	No
19	M	4	60	No	Visceral pleura, epicardium, thymus
20	M	3.5	60	No	Visceral pleura, thymus
21	M	11	60	No	Visceral pleura
22	F	4	80	Single PET at the left conjunctiva	Visceral pleura, thymus
23	F	9	90	No	Parietal pleura, pericardium, epicardium, thymus
24	F	6	90	No	Visceral pleura

Precise information about the duration of the reanimation was available in these 24 cases

Table 4 Characteristics of the cases registered as asphyxia

Case	Type of asphyxia	Cutaneous PET	Conjunctival PET	Position at discovery	CPR
1	Smothering, soft cover	No	No	Supine	No
2	Smothering, soft cover	Eyelids	Multiple right, isolated left	Unknown	No
3	Smothering, soft cover	No	No	Supine	No
4	Aspiration of gastric content	No	No	Supine	No
5	Aspiration of gastric content	No	No	Prone	No
6	Aspiration of gastric content	No	No	Prone	No
7	Smothering, soft cover	Few, left frontal region, hypostasis	No	Supine	Yes
8	Drowning	No	Very few, bilateral	Unknown	No
9	Choking	Rare eyelid, bilateral	Very few, bilateral	Supine	Yes
10	CO intoxication	Single PET, eyelid	No	Supine	Yes
11	Drowning	Numerous, face, eyelids	Multiple, bilateral	Prone	Yes
12	Aspiration of gastric content	No	No	Supine	No
13	Choking	No	No	Supine	No

those of the aforementioned and do agree that asphyxial deaths are usually associated with external PET.

We have also observed external PET in deaths due to airway infection, the prevalence being about the same (4–10%) as in SIDS (5–9%). We would suspect that airway infection, especially when accompanied by coughing fits of the spastic type, is associated with intrathoracic pressure increase and arterial pressure waves as well. Also, the fact that SIDS is sometimes associated with PET might have similar explanations; indeed, among the 33 cases in the SIDS category 1 group, external PET could be observed in only one case, while in the groups of categories 2 and 3, their prevalence is higher. Moreover, there have been observations that SIDS in its final phase can be associated with glottis obstruction [2, 37] and that babies are very susceptible to this reaction type even if healthy. It can well be understood that this reaction is associated with PET. The intensity of PET was not a good differential diagnostic criterion in this study, in accordance with previous reports [4, 11].

CPR has been regarded as a possible reason for causing PET [22]. Our study does not show any correlation between CPR, its duration and PET; these results have to be taken with caution because of the low number of PET positive cases both in the resuscitation and non-resuscitation groups and great heterogeneity in the type of resuscitation (very different duration, professional versus non-professional, immediately after cardiac arrest, many minutes afterwards). Theoretically, at least CPRs lasting longer than 30 min require special attention because they are associated with predisposing factors (Valsalva-like mechanism due to intubation and superimposition of pressure-induced inspiration and pressure massage of parts of the thorax) and the infants can acquire hypoxic capillary damage. Since this subgroup is unfortunately very small, a definite conclusion cannot be made. Anyway, considering the special characteristics of CPR in infants, we do not exclude that, in exceptional cases, i.e. imprecise or wrong reanimation manoeuvres performed by not trained personnel (such as the parents before the arrival of the emergency physician) can cause PET.

Our study confirms that the presence of cutaneous and/or conjunctival PET in infants has to be considered a suspicious finding requiring careful evaluation. If conjunctival and/or cutaneous PET are detected at autopsy, infanticide through compression of the neck or the thorax as well as other forms of asphyxia has to be considered. If PET is associated with findings such as bleedings in the neck muscles or vital reactions associated with oronasal occlusion, then this can be crucial evidence of external asphyxiation. On the other hand, if external PET remain an isolated finding, the diagnosis of asphyxiation requires caution. Because of the numerous factors that can cause PET, the investigation has to be as complete as possible to avoid wrong diagnosis. With regards to the extent of the investigation, the protocol introduced by the *Soria Moria working group on SIDS* can be recommended [6] as well as the paper published by the members of the working group *Forensic–Paediatric Diagnostics* of the *German Society of Legal Medicine* [38]. An extensive histology is a mandatory part of the investigation [17] and essential in order to identify possible natural explanations for PET.

Conclusion

The results show that external PET can occur in cases of natural death such as SIDS or infections. The knowledge about these facts led to the conclusion that, for differentiation between unnatural and natural death of infants, a complete autopsy including additional investigations (histology, microbiology/virology, toxicology and clinical chemistry), an analysis of the circumstances of death and a review of the clinical history is indispensable [24, 32, 33].

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