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Rib fractures in children – resuscitation or child abuse?

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Summary. The autopsy reports of 233 babies and children aged between 5 days and 7 years, including 190 cases of non-traumatic and 43 cases of traumatic death, were reviewed. In 94 out of 190 cases of death due to natural causes, attempted resuscitation (closed-chest massage) was performed and only in 2 cases could fractures of the ribs localized on both sides in the midclavicular line be observed. In 15 of the 43 cases of death due to traumatic events, fractures mainly of the posterior ends of the ribs occurred. These observations support the published findings of other authors which indicate that fractures of ventral parts of the thorax can occur during resuscitation. Fractures localized in particular in dorsal parts of the chest wall of infants without metabolic bone diseases, however, must be interpreted as a strong indication of physical child abuse. It was observed that relevant injuries due to resuscitation are caused much more frequently or almost exclusively by physicians than by non-medical persons. This finding refutes any possible claims that rib fractures were caused by inexpert resuscitation in a panic-like reaction.

Key words: Child abuse – Rib fracture – Resuscitation

Zusammenfassung. Es wurden die Sektionsprotokolle von 233 Säuglingen und Kindern in einem Alter zwischen 5 Tagen und 7 Jahren ausgewertet (190 Fälle mit nicht-traumatischer und 43 Fälle mit traumatischer Todesursache). In 94 der 190 nicht-traumatischen Todesfälle waren Reanimationsmaßnahmen einschließlich Herzdruckmassage durchgeführt worden. Lediglich zweimal war es zu Frakturen der Rippen beidseits in der mittleren Klavikularlinie gekommen, hingegen ließen sich in 15 der 43 Fälle mit traumatischer Todesursache Brüche hauptsächlich der paravertebralen Anteile der Rippen feststellen. Die Ergebnisse bestätigen, daß Rippenbrüche bei Säuglingen bzw. Kindern im Rahmen von Wiederbelebungsmaßnahmen ein sehr seltenes Ereignis darstellen und v. a. dorsal lokalisierte Brüche müssen – bei Fehlen von Skeletterkrankungen – als nahezu eindeutige Hinweise auf körperliche Mißhandlung angesehen werden. Die Beobachtung, daß schwerwiegende Reanimationsverletzungen weit überwiegend bzw. nahezu ausschließlich im Rahmen ärztlicher Wiederbelebungsversuche auftreten und nicht von medizinischen Laien gesetzt werden, kann ferner als Argument gegen die mögliche Einlassung, die Verletzungen seien aufgrund von Panik und "Schock" durch die betreuende Person induziert worden, gewertet werden.

Schlüsselwörter: Kindsmißhandlung – Rippenbruch – Reanimation

Introduction

Physical child abue is a major medico-legal and pediatric problem and the detection depends mainly on the diagnosis of typical patterns of injuries [10]. The "battered child syndrome" comprises a variety of injuries in particular intracranial and retinal haemorrhages in combination with skull fractures [1, 3, 5, 6, 9, 11, 12]. In addition to severe lacerations of internal organs [18], fractures can be observed following child abuse such as corner fractures of the long bones of the leg and fractures of the thoracic cage [7, 17]. Rib fractures are caused mainly by squeezing the baby's chest with the hands or severe shaking [2, 8] and injuries to the rib cage of different ages indicate – especially in combination with the above mentioned pattern of injury – almost unambiguously that child abuse has occurred. In fatal cases resuscitation has often been performed and a variety of "possible" explanations for the different injuries are given by suspects [5]. The question therefore arises as to whether rib fractures of the chest of a baby or a child can also be caused by external cardiac massage.

Material and methods

In the period 1990–1992, 233 babies and children aged between 5 days and 7 years were autopsied in the Department of Legal Medicine of Munich. In all autopsies the absence or presence of injuries of the chest wall such as rib fractures or haemorrhages in the connective tissue of intercostal spaces were routinely recorded. The cause of death ranged from the "sudden infant death syndrome (SIDS)", congenital heart defects (CHD), infectious diseases and

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drowning in cases of non-traumatic death (n = 190); the traumatic events (n = 43) included car accidents, falls, chest compression and child abuse.

The cases of non-traumatic death in which external cardiac massage was performed were selected and the autopsy reports were evaluated for the presence and localization of rib fractures as well as of injuries of internal organs (heart, lungs, liver and spleen) which could have been traumatized in the process. Furthermore, a differentiation was attempted between cases in which resuscitation was carried out by parents or other non-medical persons and/or by physicians to investigate whether the closed-chest massage carried out by non-medical persons caused more severe injuries. Non-manual resuscitation measures such as mechanical extracorporal circulation were not performed in the evaluated cases.

Results

In 94 out of 190 cases of non-traumatic death (49%) cardiopulmonary resuscitation including external cardiac massage was performed. In 64 of these 94 cases (68%) the measures were carried out exclusively by physicians, in 11 cases (12%) by the parents and in 15 cases (16%) both by non-medical persons, in particular the parents, and by physicians. In the remaining 4 cases (4%) it remained unknown who actually performed the resuscitation.

Injuries due to resuscitation (closed-chest massage) included contusion of the lungs (7 cases, 7%) as the most common injury. Since there was no typical distribution of the contusions which were observed mainly in peripheral and central parts of all lung lobes a detailed documentation of the localization of this pattern of injury was not performed. In one of these 7 cases, a slight haemothorax was detectable. In 2 further cases a haemoperitoneum was observed probably due to puncture of pelvic vessels since no apparent injuries of internal organs or other alterations which could explain the intraperitoneal blood were detected. In another case, there was a slight bleeding in the connective tissue of the intercostal spaces but no rib fractures were found. Only in two cases could rib fractures be detected which were localized in the midclavicular line on both sides. A 3-year-old child who died due to drowning showed injuries to internal organs (small lacerations of spleen and diaphragm, haemothorax and haemoperitoneum) but no rib fractures. The performer of the resuscitation measures remained unknown since repeated external cardiac massage was carried out by the parents and the first aid doctor.

In 11 of these 13 cases (85%) with obvious injuries, the resuscitation measures were performed exclusively by physicians. Injuries (lung contusions) were detected in only 1 out of 20 cases (5%) in which the parents were involved in the resuscitation but no other alterations occurred.

In 15 out of the 43 cases (35%) dying of traumatic events, rib fractures were observed and in 11 of these 15 (73%) the posterior parts of the ribs were involved.

Table 1. Age distribution and cause/causation of death in 137 infants (94 cases of non-traumatic death and attempted resuscitation – 43 cases of traumatic death)

Cause of death	Number of cases	≤1 year	≤2 years	≤7 years
SIDS	60	60	0	0
Drowning	18	1	5	12
Congenital heart defects (CHD)	8	8	0	0
Infection	7	2	2	3
Epileptic seizure	1	0	0	1
Car accident	24	8	7	9
Fall	6	0	1	5
Traumatic asphyxia	5	0	0	5
Child abuse	8	5	2	1

Table 2. Distribution and localization of the injuries due to closed-chest massage (mcl: midclavicular line, CHD: congenital heart defects)

Performer	Rib fractures	Haemothorax	Haemoperitoneum	Other injuries	Age	Cause of death
Physician	–	–	–	Bleeding in the connective tissue of intercostal spaces	17 days	CHD
Physician	–	–	–	Lung contusion	9 days	CHD
Physician	–	–	–	Lung contusion	1 month	SIDS
Physician	II–V on both sides in mcl	–	–	–	2 months	SIDS
Physician	–	–	–	Lung contusion	2.5 months	SIDS
Physician	–	–	+	–	4 months	SIDS
Physician	–	–	+	–	5 months	SIDS
Physician/parents	–	–	–	Lung contusion	6 months	SIDS
Physician	–	–	–	Lung contusion	8 months	SIDS
Physician	–	–	–	Lung contusion	2 years	Drowning
Physician/parents[a]	–	+	+	Small laceration of spleen and diaphragm	3 years	Epileptic seizure
Physician	II–VI on the right side in mcl	–	–	–	5 years	Drowning
Physician	–	–	–	Lung contusion	7 years	Drowning

[a] It remained unclear who caused the injuries since repeated external cardiac massage was carried out by parents and first aid doctor

Table 3. Localization of rib fractures in infants with traumatic causes of death (al: axillar line – pv: paravertebral – mcl: midclavicular line)

	Age ≤ 1 year	≤2 years	≤7 years
Child abuse (total number: 8)	Case 1: II–IV al (right) II pv (left) Case 2: V–VIII al (right) II–X pv (left) Case 3: I–XI pv (left) left clavicula	Case 4: I–IV pv (right)	Case 5: VII–X pv (left)
Car accident (total number: 24)	Case 1: III–VII pv (right) II–IV mcl (left) Case 2: left clavicula Case 3: V pv (right)	Case 4: I–IV pv (right) Case 5: I–II mcl (both sides)	Case 6: I–VII pv (left) IV–VII pv (right)
Fall (total number: 6)		Case 1: V–VII pv (left) II–IV al (left)	Case 2: I, II, IV–VIII pv (left) Case 3: left clavicula Case 4: VII–VIII al (right)
Traumatic asphyxia (total number: 5)			Case 1: I–III al (left)

Relevant differences in the frequency or distribution of rib fractures dependent on the age of the infants could not be detected in cases of non-traumatic or traumatic death.

Discussion

Rib fractures, especially of different duration, are strong indications of physical child abuse and are mainly caused by squeezing the baby's chest with the hands or severe shaking [2, 8].

The elasticity of the infant's chest enables it to tolerate considerable compression without giving rise to rib fractures while these injuries can be observed in a high percentage of resuscitated older individuals [14]. This elasticity would explain our observation that in infants slight "injuries of internal organs" such as contusions of spleen, liver, heart or lungs and haemothorax or haemoperitoneum are more frequent than injuries of the skeleton but severe lacerations of internal organs are not easily conceivable following resuscitation of infants. Other authors, however, report that rib fractures due to anterior-posterior compression are a more common type of severe injury following closed-chest massage [15, 17] while in other studies no rib fractures were observed in resuscitated infants [4]. Analyzing the localization of the rib fractures following external cardiac massage Saternus and Oehmichen [15] reported that these injuries were exclusively localized in ventral parts of the thoracic cage. In our series, the rib fractures also exclusively involved ventral parts of the chest wall but Thomas [17] found rib fractures in posterior parts in 3 out of 25 infants dying of natural death. These premature infants, however, showed severe metabolic bone diseases (Maladie de Rossier, i.e. bone dystrophy and osteomalazia of extreme premature infants [13] or rickets) which could explain this unusual localization of rib fractures following resuscitation while the other children showed rib fractures exclusively of lateral or especially ventral parts of the ribs.

In contrast, injuries of the posterior ends of the ribs are frequently observed in cases of physical child abuse. Thomas [17] reported 6 cases of child abuse and in all of these infants paravertebral fractures of the ribs were found. In our series, 5 out of 8 physically abused children showed rib fractures and in all of these 5 cases the posterior ends of the ribs were involved. This pattern of bone injury is regarded as a result of lateral compression of the thorax following squeezing of the chest [2] hitting the child from behind or being trodden on [16]. However on the basis of clinical observations Kleinman saw little evidence to support these views and regards severe shaking as the responsible mechanism leading to a front to back compression of the thoracic cage with levering the ribs over the fulcrum of its transverse process and to a disruption of the ventral cortex and periosteum if sufficient force is developed [8]. Since this mechanism assumes similar forces applied to adjacent ipsilateral ribs, it would explain the frequent occurrence of a row of posterior fractures involving numerous ribs as also observed in most of our cases of physical child abuse. Fractures along the lateral arcs of the ribs can also be regarded as secondary to anterior-posterior compression during severe shaking [8].

According to these previous studies and to our results, it must be emphasized with respect to the different localization and frequency of rib fractures due to resuscitation or traumatic events that rib fractures in infants (without metabolic bone diseases) which are localized in dorsal parts of the chest wall must be regarded as a very important finding which form – in particular in combination with other injuries – the basis of the diagnosis of physical child abuse.

Another interesting result of our study was that injuries following resuscitation attempts are mainly or almost exclusively caused by physicians but not by non-medical persons, supporting the former findings of Saternus and Oehmichen [15]. This observation could be explained by the hypothesis that non-medical persons, in particular the parents, are more cautious when performing

the closed-chest massage since they are more afraid of causing severe injuries. Therefore, this result could be interpreted as an argument against a possible claim of a suspect that fractures of the ribs are caused by inexpert resuscitation following panic and shock of the worried father or mother.

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