Clin Orthop Relat Res (2011) 469:759–767
DOI 10.1007/s11999-010-1565-4

SYMPOSIUM: NONACCIDENTAL TRAUMA IN CHILDREN

The Epidemiology of Nonaccidental Trauma in Children

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Published online: 21 September 2010

Abstract

Background Abuse of children is abhorrent in Western society and, yet, is not uncommon. Nonaccidental trauma (NAT) is the result of a complex sociopathology. Not all of the causative factors of NAT are known, many are incompletely described, not all function in each case, and many are secondary to preexisting pathology in other areas.

Questions/purposes We therefore addressed the following questions in this review: (1) what is the general incidence of NAT; (2) what factors are intrinsic to the abused child, family, and society; and (3) what orthopaedic injuries are common in NAT?

Methods We searched Medline, Medline In Process & Other Non-Indexed Citations, and Embase using OVID. Only one article fit our inclusion criteria; therefore, this is a descriptive generalized review of the epidemiology of NAT.

Results The general incidence of NAT ranges from 0.47 per 100,000 to 2000 per 100,000. Younger children are at greater risk of NAT than older children. Parents are often the perpetrators of the abuse. Rib fractures are highly indicative of NAT in young children.

Conclusions It is important to consider child, family, and societal factors when confronted with suspicions of child abuse. Our review demonstrates the currently limited information on the true incidence of NAT. To determine a much more accurate incidence of NAT, there needs to be a population-based surveillance program conducted through primary care providers.

Introduction

Despite the abhorrence of abuse of children in Western society, it is not uncommon. The term "nonaccidental trauma" (NAT) is frequently used because of its more neutral connotations. NAT is the result of a complex sociopathology. Not all of the causative factors are known, many are incompletely described, not all function in each case, and many are secondary to preexisting pathology in other areas. There are many confounding factors in diagnosis (bias, underreporting, real and hypothetical bone fragility). The complexity of the problem defies simple deconstructive analysis.

The complexity of the problem is reflected in the heterogeneity of the literature. There is a wide range in the reported incidence of NAT, ranging from 0.47 per 100,000 to 2000 per 100,000 [2, 43]. A wide range of risk factors have been investigated, including birth order and family structure to whether the perpetrator had been abused as a child [3, 6, 14, 30, 34]. Studies reviewing orthopaedic injuries as a result of NAT are a bit more homogeneous with fractures in some bones being clearly more related to NAT than others [27, 31, 39].

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.
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This review addresses epidemiologic factors related to the maltreatment of children and focuses on physical abuse. Our goal in this review is to provide a rich descriptive background. The questions addressed in this review are: (1) what is the general incidence of NAT; (2) what risk factors are intrinsic to the abused child, family, and society; and (3) what orthopaedic injuries are common in NAT?

Materials and Methods

A search strategy was developed in consultation with a medical librarian to find epidemiologic studies of fracture in NAT (Appendix 1). The MeSH heading child abuse with the epidemiology filter as well as fracture and bone were included in the search. Key word searches included child abuse, synonyms for child abuse, orthopaedics, and fracture using appropriate wild card symbols and truncation. We searched Medline, Medline In Process & Other Non-Indexed Citations, and Embase using the OVID interface.

The search identified a total of 187 unique titles (Fig. 1). Abstracts of the articles were obtained and reviewed. We included a study only if it: (1) addressed the epidemiology of NAT in children; and (2) was a population-based surveillance study. One article fit these criteria [43]; therefore, it was decided to present a more generalized review of the epidemiology of NAT by exploring common themes in the abstracts returned in our literature search. Additional papers were identified through the reference lists of these papers. Ultimately, the articles included in this review were selected using expert opinion.

The studies included in this review were performed primarily in the United States, the United Kingdom, and Australia. Two additional studies were from Canada and Finland. Study designs included retrospective (n = 21), case-control (n = 9), review article (n = 4) prospective (n = 3), cross-sectional (n = 3), other (n = 2), retrospective with a prospective component (n = 1), expert opinion (n = 1), and randomized controlled trial (n = 1).

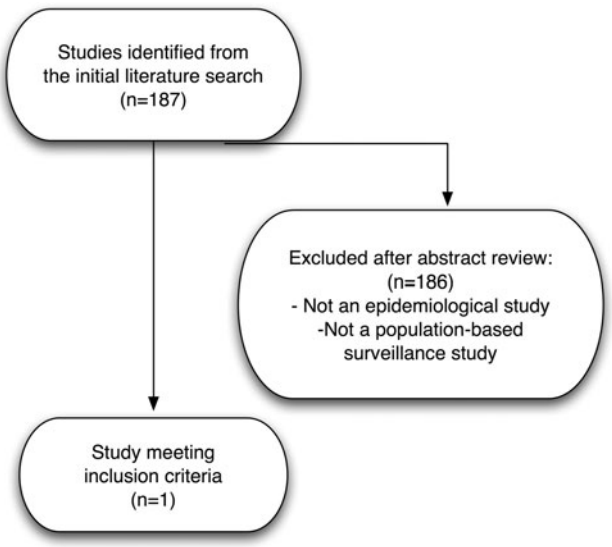

Fig. 1 A flow diagram of the article selection process is shown.

Results

Incidence

The general incidence of NAT ranges from 0.47 per 100,000 to 2000 per 100,000 [2, 3, 9, 10, 43] (Table 1). The lowest reported incidence of 0.47 per 100,000 was from a population-based study in Wales in the 6- to 14-year-old age group [43]. The reported incidence may vary based on age group [43], the year in which the study was performed [10], and study design [3].

Risk Factors

Risk factors for NAT can be broadly categorized into: (1) risk factors intrinsic to the child; (2) risk factors intrinsic to the perpetrator of abuse; and (3) risk factors intrinsic to family structure and society.

Several studies have tried to identify risk factors that predispose a child to NAT. Gender, age, race, and the child's health status have been investigated. There is no consensus on gender being a risk factor [3, 28, 39, 47]. However, one study did report a substantial bias toward males in a review of children who sustained fractures as a result of NAT [28]. The risk of NAT is inversely related to the age of the child with most victims being younger than 2 years of age [1, 3, 25, 43]. There are mixed results regarding whether a particular race is at greater risk for experiencing NAT [9, 24–26, 28]. Of note, black children have a greater risk of mortality from NAT [16, 34]. Children who are born prematurely or with concomitant medical conditions are at higher risk of experiencing NAT [3, 10, 22, 30, 35, 42, 44].

Major themes for developing a profile for the perpetrator of abuse are gender, relationship to the child (Table 2), age of the perpetrator (Table 3), and whether the perpetrator had been abused as a child (Table 4). The perpetrator of NAT is likely to be a young parent or primary caregiver and female. Males are more likely to be responsible for episodes of NAT resulting in death. Data regarding whether abusive parents were more likely to have been abused as children are mixed. Various other potential risk factors have also been identified (Table 5).

Table 1. General incidence of nonaccidental trauma

Reference	Study description	Incidence of abuse	Comments
Altemeier et al. [2]	1400 low-income mothers interviewed while pregnant; followed prospectively; 23 subsequently abused their children	2000/100,000	
Baldwin and Oliver [3]	Retrospective case-control and prospective case reports; 38 children from 34 families; severe abuse; retrospective 1965–1971 and prospective January 1972–June 1973	37/100,000	Retrospective arm of study
		96/100,000	Prospective arm of study
Cappelleri et al. [9]	Data from the Second National Incidence and Prevalence Study of Child Abuse and Neglect	495/100,000	
Creighton [10]	Retrospective review; 6532 children on abuse register 1977–1982	43/100,000	In 1979
		63/100,000	In 1982
Sibert et al. [43]	Population-based incidence	73.4/100,000	In babies younger than 1 year
	Study 1996–1998; children	9.2/100,000	Children 1–4
	younger than 14; severe abuse	0.47/100,000	Children 5–14

Table 2. Identity of the perpetrator of abuse

Reference	Study description	Female	Male	Both	Parent/ caregiver	Other relative or parent's boyfriend or girlfriend
Baldwin and Oliver [3]	Retrospective case-control and prospective case reports; 38 children from 34 families; severe abuse	47%	12%	41%		
Benedict et al. [6]	Retrospective case-control; mothers of 532 abused children matched for child age and gender, maternal care, and maternal education	39%	18%	2.5%	60%	13%
Lightcap et al. [30]	24 two-parent families with a documented history of abuse	33%	67%			
Lyman et al. [34]	Retrospective review of child homicides younger than 6 years of age	36%	64%		61%	23%
Perez-Arjona et al. [39]	Retrospective review of Department of Health Statistics				75%	11%

The role of family structure in NAT has also been investigated. In one study, the eldest child had the highest risk of abuse [44], whereas in another, the second child was identified as having the highest risk of abuse [3]. When the parental feelings a parent or caregiver has for a child are weak, the risk of mistreatment by that parent or caregiver is increased [12]. This has implications for stepchildren [13, 30] as well as for children with whom the natural parents do not bond [10, 33, 36, 45].

Societal factors affecting NAT include socioeconomic status and lack of community support. Socioeconomic factors are sometimes believed to play a role in the incidence of NAT. Several studies report no difference in abuse and nonabuse groups based on socioeconomic status [2, 16, 28, 44]. Isolation and lack of community support are common themes in the NAT literature (Table 6). Abuse is more common when the parent perceives there is little community support and when families feel a lack of connection to the community.

Orthopaedic Injuries in NAT

Orthopaedic injuries are a common feature of NAT. One study using data from the Kids' Inpatient Database found 12.08% of children hospitalized with fractures sustained those fractures as a result of NAT [27]. NAT was second only to falls as the cause of fractures requiring hospitalization. Fractures in young children should raise suspicion for NAT (Table 7). Twenty-five percent of children who were hospitalized with a fracture in the first year of life were abused.

Fractures in certain bones and specific fracture types are more common in NAT than in accidental injury (Table 8). In a retrospective review of all children younger than age 3 with rib fractures within a 6-year period, the positive predictive value of a rib fracture as an NAT was 95% [5]. In 29% of these children, rib fractures were the only orthopaedic injury caused by NAT. The number of fractures may provide a clue toward whether the injury was

Table 3. Age of perpetrator of abuse

Reference	Study description	Results	Comments
Benedict et al. [6]	Retrospective case-control; mothers of 532 abused children matched for child age and gender, maternal care, and maternal education	Mean age of mother in abuse group 20.7 ± 4.6 versus 21.8 ± 5.6 years	Statistically significant; larger proportion of mothers in the 17–19 age group in the abuse group
Lauer et al. [25]	Retrospective case-control; 130 abused children	Median age of mothers in abuse group 22.5 versus 26.5 for control subjects; median age of fathers in abuse group 25.2 in abuse group versus 42% of control subjects; 21% of mothers were 19 years of age or younger versus 8% of control subjects	Difference in the parents' age between the two groups was statistically significant
Lynch and Roberts [35]	Retrospective case-control 50 abused children	50% of mothers in the abuse group were 20 years or younger at birth of her first baby versus 16% of control subjects; 20% of mothers in the abuse group were 20 years or younger at birth of the index child versus 8% of control subjects	Difference was statistically significant for age at birth of first child but not for birth of index child
Perez-Arjona et al. [39]	Retrospective review of Department of Health Statistics	80% of perpetrators younger than 40 years Mean age of females: 31 years Mean age of males: 34 years	Descriptive statistics only
Smith and Adler [44]	Case-control; controlled for social class; 45 hospitalized abused children	Mean age of mother in abuse group 25.9 ± 7 versus 29.6 ± 6 in control subjects; Mean age of father in abuse group 28.1 ± 8 versus 32.2 ± 9 in control subjects	Both are statistically significant

nonaccidental. In a series of 35 children with fractures sustained as a result of NAT, 54% of the children had a history of three or more fractures [47]. In the group of 116 control subjects, no child had more than two fractures; 84% of the children had only one fracture.

Discussion

NAT is the result of a complex sociopathology. There is a lack of true epidemiologic studies of fracture sustained as a result of NAT. As a result of the heterogeneity of the literature, we identified common themes present in the NAT literature and touched on the wide range of research that has been undertaken. This review sought to address three topics: (1) the incidence of NAT; (2) risk factors for NAT; and (3) orthopaedic injuries in NAT.

There are limitations inherent in NAT research. First, there may be challenges around collecting data and conducting research in NAT as a result of privacy laws and fear of litigation. Second, each of the risk factor analyses in any given paper is subject to bias. It is important to take into account the study's sample size and the possibility of type II error.

Our literature review was also limited in several ways. First, we were limited in our ability to conduct a systematic review of true epidemiologic studies of NAT because only one population-based surveillance study was found in our literature search that fit our inclusion and exclusion criteria. Therefore, we proceeded with a descriptive article. The strict inclusion criteria for study design were set because a population-based surveillance program is the purest way to conduct an epidemiologic study. Second is the heterogeneous nature of those papers selected for inclusion. Definitions of NAT varied; some studies looked only at severe trauma or death, whereas others combined physical abuse with other types of abuse or confirmed cases of physical abuse with suspected cases of physical abuse. Third, various study designs were used, including retrospective chart reviews, database searches, case-controls, matched cohort studies, and prospective designs. Data from retrospective studies and databases may have over- or underestimated the true incidence of NAT. Fourth, although heterogeneous in many respects, the papers were also somewhat homogeneous with regard to the countries in which they were performed. Almost all studies were performed in the United States, the United Kingdom, and Australia. Butchart noted "almost all scientifically robust epidemiological studies of child mal treatment…have been conducted in high income countries," which in and of itself can be a confounding factor [8].

There is little information on the true incidence of NAT. Although general statistics can give a clear picture of those

Table 4. Abusive parents who experienced abuse as children

Reference	Study description	Results	Comments
Altemeier et al. [2]	1400 low-income mothers interviewed while pregnant; followed prospectively; 23 subsequently abused their children	17% were beaten more than two times by parents; 9% saw a doctor for a beating by a parent; 43% were punished by abuse as children	No statistically significant difference between mothers who abused their children and those who did not in these areas
Baldwin and Oliver [3]	Retrospective case-control and prospective case reports; 38 children from 34 families; severe abuse	41% of parents were abused as children	
Disbrow et al. [14]	Case-control; 37 abusive families 32 control subjects; matched for age of child, and age, education, race, and relationship status of mother	Abusive parents more likely to have been abused as children	This was a statistically significant difference Tau coefficient 0.40
Egeland et al. [15]	Prospective longitudinal study of 267 primiparous women; low socioeconomic group; 161 women interviewed when her child was 48 or 54 months old	47 of 161 mothers were abused as children; 18 of the 47 women abused their children; 12 did not and 12 were "borderline"	
Haapasalo and Aaltonen [21]	25 mothers who had had contact with child protective services (CPS) and 25 who had not; matched for mothers' and children's ages and gender, and number of children	All mothers in CPS group reported a history of physical abuse; 23 of 25 reported a history of physical abuse in the non-CPS group	
Hunter et al. [23]	Prospective review of 255 premature births with abuse rate of 3.9%	90% of the families in the abuse group had a family history of abuse or neglect compared with 17% in the no abuse group	This was a statistically significant difference
Smith and Adler [44]	Case-control; controlled for social class; 45 hospitalized abused children	47% of mothers and 33% of fathers in the abuse group had a history of abuse compared with 16% and 13%, respectively in the control group	Both were statistically significant differences
Smith and Hanson [45]	214 parents of battered infants and children less than 5; 53 control subjects	No difference in incidence in abuse as children	

Table 5. Other factors that have been associated with perpetrators of nonaccidental trauma

Increased life stressors [2, 15, 19, 44]
Decreased self-esteem [2]
Easy to anger [2]
Depression [15, 45]
Aggressive [2]
Punished "unfairly" as a child [2]
Relationships with parents more negative [2]
Parent was in foster care or abandoned as a child [2, 3]
Less likely to have a close relationship with the child's father/other biological parent [2, 44]
Has lost child to foster care or avoidable death [2]
Unplanned pregnancy [2]
Unwanted pregnancy [2]
Engages in criminal activity/violence as an adult [3, 37]
Chronically ill or disabled [3]
Personality disorder [3, 23, 37]
Borderline to moderate intellectual impairment [3, 37]
External agency support needed [3]
History of suicide attempt(s) [37]
More likely to use physical punishment [45]
Parents "undervigilant" about child's whereabouts [45]
Less prenatal care [6]
Clumsy [45]
Parents used significant harsh corporal punishment [36]
Has relationship problems with other adults [47]
Increased number of separations from the child in the first year [44]
Shorter birth intervals [6]
Frequent change of adults in charge of children (spouses, cohabitees, relatives, etc) [3]

cases correctly diagnosed as NAT, they omit "near misses" and cases that are misdiagnosed or are not reported [4, 46]. One study has also suggested there is a bias toward referring minority children for bone scans to investigate other injuries and to child protective services [24]. Reports of incidence may also be impacted by children who experience recurring episodes of NAT. The reported risk of recurrence ranges from 9.3% to 43.8% [17, 18, 25, 29]. To determine a much more accurate incidence of NAT, there needs to be a population-based surveillance program conducted through primary care providers, similar to the study conducted in Wales [43]. Every child would need to be seen and assessed every 6 months until age 5 [43]. The assessment would include a detailed examination for evidence of abuse and determination of the risk factors for abuse present in the child's life. Implementing a large population-based surveillance program would have several challenges, including recruitment, compliance with followup, and the cost of running such a program. Despite

Table 6. Social isolation and community support

Reference	Study description	Findings
Crittenden [11]	Case control; 121 mother-child dyads in each group; same neighborhood	No difference in size or composition of maternal social network; mothers who mistreated their children did not see others as a possible source of help; did not think they were competent to enlist help; were unable to express empathy for others; and engaged in nonreciprocal interactions aimed at coercing others to meet their needs
Garbarino and Crouter [19]	Retrospective case series of abusive families	Abuse correlates with family mobility and stability of the neighborhood
Garbarino and Kostelny [20]	77 communities in the Chicago area; socioeconomically similar	In poor communities where the attitude toward the community was negative, abuse rates were high; in poor communities where the attitude toward the community was positive, abuse rates were low
Hunter and Kilstrom [22]	Case control; premature infants admitted to an intensive care unit; history of abuse in parents in 49/255	Nongeneration-repeating families had a richer network of social connections
Lauer et al. [25]	Retrospective case-control of 130 abused children; 130 control subjects	66% of families had lived at their current address less than 10 months; only 5% had kept their location unchanged for 30 months or longer
Polansky et al. [40]	Retrospective case-control; 152 "neglectful" mothers and 154 control subjects in the same neighborhood	"Neglectful" mothers viewed neighborhood as less friendly and helpful

Table 7. Age of children sustaining fractures as a result of NAT

Reference	Study description	Comments
Leventhal et al. [28]	Incidence of fractures in hospitalized children resulting from abuse; used Kids' Inpatient Database	Incidence of fractures caused by NAT by age group: age 11 months or younger: 36.1 per 100,000 age 12–23 months: 4.8 per 100,000 age 24–35 months: 4.8 per 100,000
Pandya et al. [38]	Analysis of trauma at a Level I pediatric trauma Center	Mean age of child presenting with orthopaedic injuries as a result of NAT was 11.8 months
Sibert et al. [43]	Population based incidence study	Incidence of fractures caused by NAT by age group: age 0–5 months: 56.8 per 100,000 age 6–11 months: 39.8 per 100,000 age 60–119 months: 0
Worlock et al. [47]	Retrospective case control	80% of children presenting with fractures as a result of NAT were younger Than 18 months old

Table 8. Fracture sites in nonaccidental trauma (NAT)

Reference	Study description	Age of patients	Fracture site	Caused by NAT (%)	Comments
Bulloch et al. [7]	Case series of 39 subjects; 1994–1997	1 year	Ribs	82%	
Leventhal et al. [27]	Incidence of fractures in hospitalized children resulting from abuse; used Kids' Inpatient Database	< 36 months	Ribs	61.4%	
			Tibia/fibula	31.1%	
			Radius/ulna	29.8%	
			Clavicle	20.7%	
			Skull	12.1%	
			Femur	11.7%	
			Humerus	9.3%	
Loder and Bookout [31]	Case study of 154 fractures in 75 children reported to child protective services 1987–1988	< 7 years	Skull		
			Rib		
			Long bones		
			"Corner" fractures		
Loder et al. [32]	Case series based on 2000 Health Care Cost and Utilization Project	< 2 years	Femur	15%	n = 1076 femur fractures
Pandya et al. [38]	Analysis of trauma at a Level I pediatric trauma Center		Non-bony head injury		5 most common injuries in NAT
			Rib fracture		
			Tibia/fibula fracture		
			Radius/ulna fracture		
			Clavicle fracture		
Scherl et al. [41]	Retrospective review of 214 femur fractures	< 6 years	Femur	8%	No difference in the number of spiral and transverse fractures in abuse group

these challenges, this type of study would provide the most accurate incidence of NAT because the number of NAT cases reported or diagnosed in the hospital setting is likely to be just the tip of the iceberg.

The results of this review highlight the complex nature of NAT. It is important to consider child, family, and societal risk factors when confronted with cases suspicious for NAT. A high index of suspicion should be maintained in cases in which the patients are young (eg, younger than 2 years of age) or have comorbid medical conditions. The perpetrator of NAT is often a young female parent or primary caregiver who has decreased feelings of attachment to the child and may feel isolated from the community or a lack of support.

When evaluating a patient with fractures, it is important to maintain a high index of suspicion when the patient is a young child with a fracture or has a history of multiple fractures. Rib fractures and "corner" fractures are particularly associated with NAT. Long bones are also commonly fractured in NAT.

Our review highlights the limited information available on the true incidence of NAT. It is likely that the incidence reported in the literature is lower than the true incidence of NAT. It is important for healthcare providers to maintain a high index of suspicion for NAT, particularly in young children, and to consider child, familial, and societal risk factors when confronted with suspicions of child abuse.

Acknowledgment We thank Dr Ranjit Varghese for his editing assistance.

Appendix 1. Search strategy

1. exp Child Abuse/ep [Epidemiology]
2. (child abuse or non-accident* injur* or battered child*).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]
3. (epidemiol* or incidence or population).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]
4. 2 and 3
5. exp Fractures, Bone/
6. orthop?ed*.mp.
7. fracture*.mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]
8. 4 or 1
9. 5 or 6 or 7
10. 8 and 9

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