Musculoskeletal Manifestations of Child Abuse: Analysis at a Level 2 Trauma Center in Puerto Rico

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Objective: To describe the epidemiological manifestations and assess major risk factors in children under the age of three years presenting with non-accidental injury (NAI) fractures in a level two trauma center in Puerto Rico.

Methods: An IRB approved retrospective descriptive study was performed by reviewing case records of 75 patients who presented with a NAI fracture at the Pediatric University Hospital of the Puerto Rico Medical Center. The study time period was from October 1996 to October 2014. The inclusion criteria for our population consisted of: (1) patients between the ages of zero to three years, (2) suffered a long bone fracture, and (3) had a history of suspected child abuse at our academic institution. The exclusion criteria were: (1) patients older than three years, (2) no history of NAI, or (3) had a congenital bone disorder.

Results: A total of 117 long bone fractures were observed in our population. Similar distribution was seen between sex,, with 52% being male and 48% being female. The mean age was 10.8 months. The group with the highest frequency of NAI fractures were children under the age of one year (57.3 %). The most commonly involved fractured bone for all age groups was the femur (48.0 %). No statistical significance was observed when comparing sex, age, associated injuries or multiple fractures.

Conclusion: Children younger than one year of age who present with long bone fracture, multiple fractures, low household income and parental unemployment are associated with an increased risk of NAI fractures. [*P R Health Sci J 2020;39:283-287*]

Key words: Child abuse, Nonaccidental injury fracture, Pediatric fracture, Femur fracture

The term battered child was first described by Kempe et al. in 1962 and consisted of a child presenting with the combination of fractures, skin bruising and subdural hematoma (1). Today, child abuse remains a diagnostic challenge to many physicians. This is due to its atypical presentation sparking a vast differential diagnosis that require thorough evaluation of patient's history, physical exam, diagnostic studies and social risk factors which may often be overlooked in the clinical practice (2,3). It is estimated that up to 150,000 cases are reported to local child protective services (CPS) agencies and more than 4,500 children are hospitalized due to physical abuse per year (2). Moreover, it is approximated that 1000 deaths occur annually due to child abuse in the United States (4). Furthermore, according to the Department of Health and Human Services, the reported incidence of child abuse in the United States is 10.3 in 1000 children (5). Failure to diagnose a case of child abuse may lead to a 30% to 50% chance of repeated abuse (6). After skin lesions, fractures are the second most common presentation of physical abuse; and only one third of the cases will eventually be evaluated by an orthopaedic surgeon (7). It is estimated that 25% of fractures occurring in children younger than 1 year and 10 to 15% of fractures in children younger than 3 years old are a result of child abuse or non-accidental injury (NAI). They also may be responsible for almost all types of certain types of fractures in children, such as rib fractures (8, 9).

Although there have been multiple studies regarding NAI fractures and child abuse (4, 6, 7, 10-13), most studies were performed in the United states and other countries. The only reported study in Puerto Rico was performed by Ishida et al. and dwells on multiple causes for child abuse (14), overlooking the

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orthopedic manifestations of non-accidental trauma, which was the main purpose of our study. To our knowledge, there are no studies performed in Puerto Rico that assess NAI fractures and their epidemiology, associated complications and risk factors. We therefore intend to report the first study on this subject in Puerto Rico that could contribute in the education of healthcare providers such as pediatricians, orthopaedic surgeons, nurses and social workers.

Patients and Methods

Through Institutional Review Board approval, we developed a retrospective case review of patients who suffered a suspected non-accidental injury (NAI) fracture and presented to the Pediatric University Hospital at Puerto Rico Medical Center in Río Piedras. Cases of patients with a NAI fracture due to suspected child physical abuse were selected from the medical records based on codes 995.59 and their variants of the International Classification of Diseases (ICD) ninth revision, and T76.12XA and their variants of the ICD tenth revision. A total of 75 patients met our inclusion criteria during the study time period of October 1996 to October 2014. The inclusion criteria for our study consisted of: (1) patients between ages zero to three years, (2) who suffered a long bone fracture, and (3) were referred to the pediatric orthopaedic surgery service by the Biopsychosocial Office at the hospital with a positive history of suspected child abuse. The exclusion criteria were: (1) patients outside the age range, (2) no history of suspected child abuse, or (3) had a congenital bone disorder that affect bone metabolism, such as osteogenesis imperfecta (OI).

Data collection was made through medical record review. Demographic information such as sex and age were collected. Age groups were created and subdivided into 4 groups for further analysis: less than 1-year-old group, 1-year-old group, 2-year-old group and 3-year-old group. Long bone fracture location and pattern, mechanism of injury, associated injuries, patient's type of health insurance, parents' civil relationship status, and parents' current employment status were obtained and analyzed.

All cases of suspicious child abuse underwent further imaging studies such as skeletal survey (bilateral views of the hands, forearms, humerus, feet, leg, femur, pelvis, spine, and skull), radionuclide bone scan in order to identify fractures in different stages of healing, and computerized tomography (CT) scan in cases in which head injury was suspected. Associated injuries such as abdominal injury, hemorrhage and metabolic bone disease were assessed through complete blood cell count, liver function test, coagulation studies and metabolic panels that included serum calcium and phosphate levels.

The mean and frequencies were calculated for quantitative variables. Comparisons between age groups, multiple fractures, sex and associated injuries were made using a Chi-square analysis. The results were considered significant if the p-value was < 0.05. All statistical analyses were performed using IBM SPSS statistics 24 version (IBM Co, Armonk, NY).

Results

A total of 117 long bone fractures were found in the 75 patients that met the inclusion criteria. Demographic information is shown in (Table 1). Similar distribution was seen between sex, where 52% were male and 48% were female. The mean age was 10.8 months (range 28-36 months). The group with the highest frequency of NAI fractures were the less than 1-year-old group with a total of 43 patients (57.3 %). A decreasing trend in fracture frequency with age was observed (Fig. 1). Fractures in the 1-year-old group occurred in 17 patients (22.7%), in the 2-year-old group occurred in 11 patients (14.7%) and in the 3-year-old group occurred in 4 patients (4.3%). Fifty-seven patients (76%) presented with associated injuries. Medicaid health insurance covered medical expenses in 39 patients (52%). It was found that 33 patients' parents were separated or divorced (44%). Fathers' current employment status were as follows: 39 were unemployed (52%), 10 were employed (13.3%), and 26 did not provide the information (34.7%). Similarly, mothers' current employment status consisted of 28 unemployed (37.3%), 10 employed (13.3%), and 36 did not provide the information (48%).

Table 1. Demographic analysis

Demographic	n (%)
Sex	
Male	39(52%)
Female	36(48%)
Age	
<1	43(57.3%)
1	17(22.7%)
2	11(14.7%)
3	4(5.3%)
Type of insurance	
Medicaid	39(52%)
Private	1(1.3%)
Unknown	35(46.7%)
Parental marital status	
Domestic partnership	14(18.7%)
Married	6(8.0%)
Separated	33(44.0%)
Unknown	22(29.3%)

Distal and proximal fractures comprised 33% of the total fractures, while 51% were midshaft fractures. The most commonly fractured bone for all age groups was the femur, with an incidence of 36 (48.0 %) as is seen in Figure 2. The fracture pattern most often present in femur fractures was a spiral pattern in 8 cases (22%) followed by a metaphyseal pattern in 7 of the femur fractures (19%). The least commonly encountered patterns were buckle, oblique, supracondylar and distal patterns, with an incidence of 14.7% each. The most common fracture pattern for tibial fractures was a transverse pattern, occurring in 3

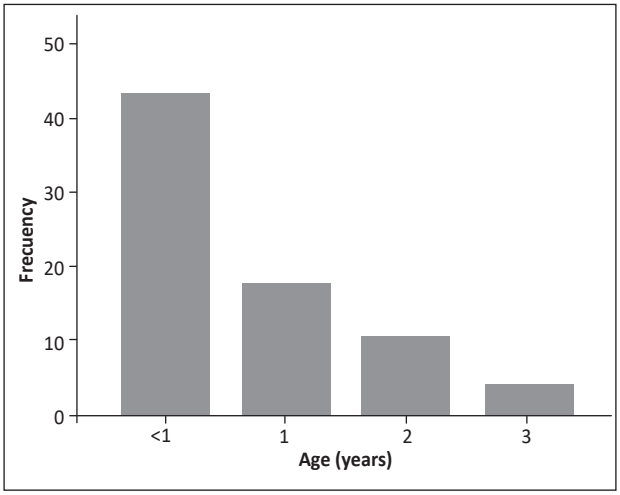

Figure 1. Age distribution of infants sustaining fractures

(15%) of the tibial fractures. Buckle, metaphyseal and diaphyseal fracture patterns occurred with an equal prevalence of 2 (10%) of all tibial fractures. The most common fracture patterns seen in the humerus were spiral and metaphyseal, each presenting in 3 (17%) of the humeral fractures. The most common fracture pattern in the ulna was transverse (2, 20%). The least commonly fractured bone was the radius (7, 9.3%). Rib fractures were seen in 15 patients for a total frequency of 20%.

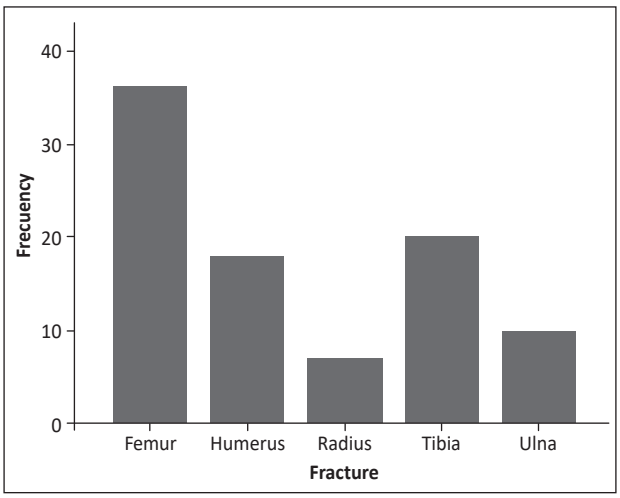

Figure 2. Type of fracture and frequency sustained in all infants

Thirty-five patients (46.7%) had a single long bone fracture at initial presentation. Two long bone fractures were seen in 12 patients (16.0%) while 3 or more fractures were seen in 28 patients (37.3%). For the less than 1-year-old group, the most commonly fractured bone was the femur (44.2%), followed by the tibia (30.2%), humerus (27.9%), ulna (16.3%) and radius (9.3%). For the 1-year-old group, the most common fractured bone was the femur (47.0%) while the other bones (tibia, humerus, radius, ulna) had an equal incidence of 17.6%. For 2-year-old group, the most commonly fractured bone was the femur (54.5%), followed by the tibia (36.3%), and humerus (18.11%). In these age groups, no ulnar or radial fractures were seen. Lastly, the 3-year-old group consisted of only 4 patients. Three of them presented with a femur fracture (75%) and 1 with a humerus fracture (25%).

For the less than 1-year-old group, 19 of the patients (44.2%) presented with multiple fractures. Six (35.3%) cases in the 1-year-old group presented with multiple fractures. Two (18.2%) in the 2-year-old group and 1 (25%) in the 3-year-old group. Statistical analyses of the comparisons of fracture multiplicity and associated injuries based on age and gender are seen in Table 2.

Table 2. Comparison of fracture multiplicity and associated injuries based on age and sex

Variables	Age	Sex
Multiple fractures	p = 0.380	p = 0.340
Associated injuries	p = 0.847	p = 0.525

The most common mechanism of injury reported was a fall or drop from height, occurring in 24 patients (32%). A presentation of battered child syndrome was seen in 17 patients (22.7%). An unknown or unwitnessed mechanism of injury was reported in 22 cases (29.4%). The most common period to seek medical care was within the same day of the presenting injury (37%) followed by less than 3 days (31%). In 23% of the cases, information of the time of injury and arrival to the emergency room was unknown. Only 7 patients (9.3%) presented with a history of previous admission. A previous history of fractures was only reported in 23 of the cases (30.7%). The most common associated injury was head trauma occurring in 57 of the cases (37%). Finally, skin injuries occurred in 21 patients (28%).

Discussion

We found a total of 75 confirmed cases of fractures associated with child abuse during the study period at our institution. Our findings were similar to other studies where sex was not an associated risk factor. The only study where there was a significant difference in sex distribution was in Singapore, a study by Gera et al. in which child abuse occurred in 73.3% of the females (11). The highest frequency of NAI fractures was seen in the less than 1-year-old group with 57.3% and a downward trend with increasing age. A similar pattern was seen in previous studies stating that fractures caused by abuse occur more often in young, non-ambulatory patients (6,11,15,16). This is in contrast to a study by Clarke et al. that showed a higher frequency of fractures in the 17-23-months group (48.0%) and the smallest in the 0-8-months group (12.2%), stating that there is a higher risk of fracture as a child's ages due to an increase in ambulatory status (10).

The most commonly fractured bone in our study was the femur and the most commonly encountered pattern was the spiral pattern. A systematic review by Kemp et al. showed no difference in distribution of pattern on femoral fractures, except for a single study showing that a spiral femoral fracture in children younger than 15 months was associated with child abuse, but no association found after 15 months of age (3). In children younger than 1 year, a femoral fracture has been associated with NAI as high as 93% of the cases (6). The tibia was the second most commonly fractured bone and the most commonly encountered pattern was the transverse pattern. Lastly, humerus fractures was the third most commonly fractured bone and the most commonly encountered patterns were the spiral and metaphyseal patterns. These pattern distributions were similar in all age groups except the 3-year-old group, which only presented with 4 cases (3 femur fractures and 1 humerus fracture). Although other studies have a shown similar pattern as our own, a study by Fong et al. found that forearm fractures were the most commonly fractured location occurring in 29.0% of the cases, while another study by Gera et al. found that humeral fractures were the most commonly fractured location occurring in 28.6% (7, 11).

We found that multiple bone fractures were associated in our patients with a similar distribution as in other studies (16-19). The most common mechanism of injury was a fall or drop from height. In only 22.7% of the cases was there a presentation of battered child and in 29.4% of the cases the mechanism of injury was unknown or unwitnessed. Most patients' parents were separated or divorced, and most medical coverage was provided by Medicaid. In our study population, the unemployment rate was high, with a greater prevalence in the male parent. These findings were similar to other studies where families were mostly classified as having low socioeconomic status and living in public housing estates (7). A study by Sedlak et al. presented that children of parents with an annual household income less than $15,000 per year were more than 25 times more likely to be abused than children from parents with an annual household income greater than $30,000 (20).

A limitation in our study was its retrospective design and data collection gathering from medical records. Documentation in some records was incomplete, and a commonly reported category was unwitnessed or unknown leading to incomplete data and potential bias. This is a common scenario in retrospective studies about child abuse, where there have been reports of incomplete records that ranges from 4 to 14% (9). Another limitation in our study was the lack of radiographs' availability, as radiographic findings were collected from the radiology report in the medical record and not from an individual evaluation by the orthopaedic surgery investigators conducting this study. This limited our ability to evaluate fracture patterns. The lack of digitalization of some of the radiographs or incomplete radiographic series in some of our patients were the main cause of this limitation. Lastly, our study was also limited by the lack of a control group with fractures due to causes other than NAI. Since our study was retrospective, a more recent more recent prospective study in the Puerto Rican pediatric population is needed to more appropriately assess the relationship between NAI fractures and its risk factors. A potential new study should consider a questionnaire for patients' parents and medical staff that can be used for the detection of NAI as well as an assessment of definitive treatment and healthcare costs. This could aid in early detection of these types of injuries, improve its management and assist social services evaluation. A potential new study should consider a questionnaire for patients' parents and medical staff that can be used for the detection of NAI as well as an assessment of definitive treatment and healthcare costs. This could aid in early detection of these types of injuries, improve its management and assist social services evaluation.

Although there have been previous studies aboutabout NAI fractures, this is the first study on our local population. Our findings were similar to other previous studies. Healthcare workers should be alerted of the potential risk factors found in this study when assessing pediatric patients. A history of children younger than 1 year presenting with a long bone fracture, multiple fractures, family history of low household income and unemployment are associated with an increased risk of NAI fractures.

Resumen

Objetivo: Describir la epidemiología y evaluar factores de riesgo significativos en pacientes pediátricos presentando fracturas no accidentales (FNA) en Puerto Rico. Métodos: Con la aprobación de la Junta de Revisión Institucional, se realizó un estudio descriptivo retrospectivo de 75 pacientes con fracturas no accidentales en el Hospital Pediátrico Universitario del Centro Médico de Puerto Rico. El periodo del estudio comenzó en octubre de 1996 y culminó en octubre de 2014. Los criterios de inclusión consistieron de: (1) pacientes entre las edades de cero a tres años, (2) con una o más FNA, y (3) con sospecha de historial de maltrato según evaluado por nuestra institución. Criterios de exclusión consistieron de: (1) pacientes mayores de tres años, (2) ausencia de historial de FNA, e (3) historial positivo de enfermedades congénitas de hueso. Resultados: Se encontró un total de 117 fracturas de hueso largo. Se observó una distribución similar entre géneros, con un 52% de masculinos y 48% de féminas. La edad promedio fue de 10.8 meses. El grupo de casos menores de un año de edad tuvo la mayor frecuencia de FNA (57.3 %). El fémur fue el hueso más comúnmente fracturado (48.0%). No se encontró alguna significancia estadística cuando las variables de género, edad, lesiones asociadas y fracturas múltiples fueron comparadas. Conclusión: Un historial de fractura de huesos largos, fracturas múltiples, e historial familiar de bajo ingreso y desempleo en pacientes menores de un año de edad están asociados a un mayor riesgo de FNA.

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