

Child maltreatment and violence. Contributions from radiologists to a comprehensive multidisciplinary approach

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ABSTRACT

The World Health Organization (WHO) defines child maltreatment as “the abuse and neglect that occurs to children under 18 years of age. It includes all types of physical and/or emotional ill-treatment [...], which results in actual or potential harm to the child’s health, survival, development or dignity.”

By examining the bodily traces of physical abuse, following the most frequently involved mechanisms of injury, it is possible to identify typical radiological patterns. The imaging studies of the bone under repair allows inferring a timeline that may be correlated to the data obtained during history taking. Health care providers should detect suspicious radiological lesions in a timely manner and promptly activate the safeguarding of the child.

Our objective was to review recent publications on the imaging studies of children suspected of being victims of physical violence.

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INTRODUCTION

In their series titled “Violence against children and adolescents,” the UNICEF defines violence as a form of exercising power through the use of force (physical, psychological, economic, political, sexual, etc.), with individually and socially harmful consequences, which implies the presence of an asymmetry of power between the one who exercises violence and the one who cannot defend themselves or repel it.¹

The long-term follow-up of child abuse victims has yielded significant data showing higher rates, compared to the general child population, of intellectual deficit, academic impairment, and a higher incidence of aggressive behaviors or social difficulties among those children who have suffered one or more episodes in their lifetime.²

The WHO estimates that, in some parts of the world, the homicide of infants and young children more than doubles that of older children, aged 5–14 years. The rate of these homicides is higher in Africa (4/100 000), followed by North America (3.4/100 000), Latin America (1.7/100 000), and finally Europe (1.3/100 000).³

In Argentina, between October 2020 and September 2021, a total of 45 589 calls to the 102 hotline (the federal system of specialized care for the rights of children and adolescents) were recorded. In order of frequency, the main reasons for consultation were physical abuse, neglect, legal questions, sexual abuse, psychological abuse, emotional abuse, and neglect.⁴

Addressing child maltreatment requires a multidisciplinary approach. In Argentina, each health care facility establishes how to proceed when faced with a child suspected of abuse, taking into consideration the protocols in force worldwide. In the future, it would be very relevant to develop a national consensus that covers all the steps that children and adolescents whose rights are violated must go through, since their first contact with the health care team.

In relation to legal responsibilities, section 30 of Act 26061 establishes that the health care team is obligated to report any case of violation of the rights of children and adolescents to the corresponding authorities, under penalty of incurring in a liability for any such omission.⁵

Within the multidisciplinary approach, radiologists play a fundamental role in diagnosis: they must be able to recognize skeletal lesions that may suggest physical maltreatment with the possibility of differentiating them from others resulting from accidents and are legally obligated

to report them. Likewise, radiologists must ensure optimal imaging conditions and repeat or add any images or incidences necessary for the comprehensive approach of their specialty. Failure to timely detect these skeletal lesions in the X-rays may result in the child being re-exposed to a dangerous and potentially fatal environment.⁶

INITIAL AND FOLLOW-UP X-RAY SCREENING

After skin lesions, bone fractures are the second most common lesions detected in child victims of physical abuse.⁷ The lack of correlation between the lesions in the child and the account of what happened by the parents or legal guardians should always lead to suspicion by pediatricians. Some fractures in childhood are highly specific or strongly suggestive of being non-accidental injuries (posterior rib, metaphyseal, scapular, sternal, and spinous process fractures) and, in some cases, they are clinically silent.⁸

Several publications in the medical literature have provided an algorithm for X-ray screening of bone lesions for a comprehensive initial assessment of pediatric patients suspected of being victims of physical abuse.⁵ The American College of Radiology (ACR) describes at least 21 conventional X-ray images that should be obtained in children under 2 years of age who are suspected victims of non-accidental trauma. They include the following axial images:

- Anteroposterior (AP) and lateral views of the skull.
 - Lateral view of the cervical spine.
 - AP, lateral, right and left oblique views of the chest.
 - Lateral view of the lumbosacral spine.
 - AP view of the abdomen and pelvis.
- And the following images of upper and lower extremities:
- AP view of the humerus.
 - AP view of the forearms (including elbow and wrist).
 - AP view of the hands.
 - AP view of the femora.
 - AP view of the tibiae (including knee and ankle).
 - AP view of the feet.⁵

It is important to note that, due to the high exposure to radiation, it is essential, within the role of radiologists, to take all the necessary precautions regarding patient care. An appropriate technique should be used, considering a high

resolution and low radiation doses, using a collimator and lead shield that limits radiation to the areas of interest, with special emphasis, whenever possible, on protecting the gonadal area.⁹

These initial images should ideally be acquired within 24 hours of suspicion and should be assessed within 24 hours of obtaining them by 2 radiologists with experience in pediatric imaging, who may add, if necessary, a complementary image or incidence.¹⁰

When analyzing the images, it is mandatory to know the radiological course of bone lesions: subperiosteal ossification is identified after 4 days, with a peak at 10–14 days; the absorption of the fracture line and the development of a soft callus, after 14–21 days; and a hard callus has a peak presentation between 21–42 days after the lesion. The final stage of bone remodeling can only be expected 1 year after the event. At this point, it is worth clarifying that such findings do not apply unequivocally to metaphyseal lesions; approximately 20% of these may normalize at follow-up at 2 weeks and most are repaired at 3 months without sequelae.⁷

In some cases, the initial radiological diagnosis is difficult, so follow-up X-ray images (11 to 14 days after the initial ones) have been indicated to assess the course of the lesion and thus

reach firm conclusions. This may be considered particularly when examining ribs and extremities; images of skull, cervical and lumbosacral spine, and pelvis are excluded if no bone lesions were observed in the initial screening.¹⁰

In order to perform a correct interpretation of the lesions, in addition to identifying them and estimating their age, it is critical for pediatric radiologists to know the child's age and medical history, in order to establish the mechanism involved in the lesion.⁷ They should rule out differential diagnoses that may cause similar lesions, considering the account of what happened and the patient's medical history.⁷ In addition, radiologists are also responsible for writing complete, accurate, and clear reports for the entire health care team.⁹

It is important to note that, in case of diagnosing child abuse, the same X-ray screening indications should be applied to all children under 2 years of age living in the same household, who may also be at risk of being victims of abuse.¹⁰

Finally, regarding brain and skull assessment, given that brain injuries may be clinically masked, the American Academy of Pediatrics (AAP) strongly advises performing a computed tomography (CT) scan of the brain without contrast in children under 1 year of age suspected of being victims of physical abuse.⁸

FIGURE 1. Fractures of rib curvatures



Frontal X-ray of the chest. Multiple fractures of middle and posterior rib curvatures (arrows).

SPECIFIC LESIONS FROM CHILD MALTREATMENT

As early as 1946, John Caffey described the association of multiple fractures in long bones and the presence of subdural hematoma in abused children; in 1957, he added metaphyseal fractures.¹¹

The AAP describes highly specific bone lesions resulting from physical abuse: posterior rib fractures, typical metaphyseal fractures, scapular fractures, sternal fractures, and spinous process fractures.⁸

Regarding the mechanism of posterior rib fractures, they occur in infants firmly held at the level of the chest and shaken forcefully. This was described by Caffey as part of the “shaken baby syndrome” in 1972.¹² In addition, typical metaphyseal fractures are those that involve the primary spongy layer of the metaphyses and are the result of vigorous pulling and twisting of the extremity. Depending on the X-ray image, lesions with a “bucket handle” or “corner” fracture may be identified.⁸ Finally, scapular, sternal, and spinous process fractures are the result of direct blows.⁷

The presence of multiple fractures and different healing times have been described by the AAP as indicating a moderate risk. Such fractures should be analyzed in relation to the patient’s age and medical history, and maltreatment should always be taken into account as a differential diagnosis. The same applies to epiphyseal separations, complex skull fractures, vertebral body fractures,

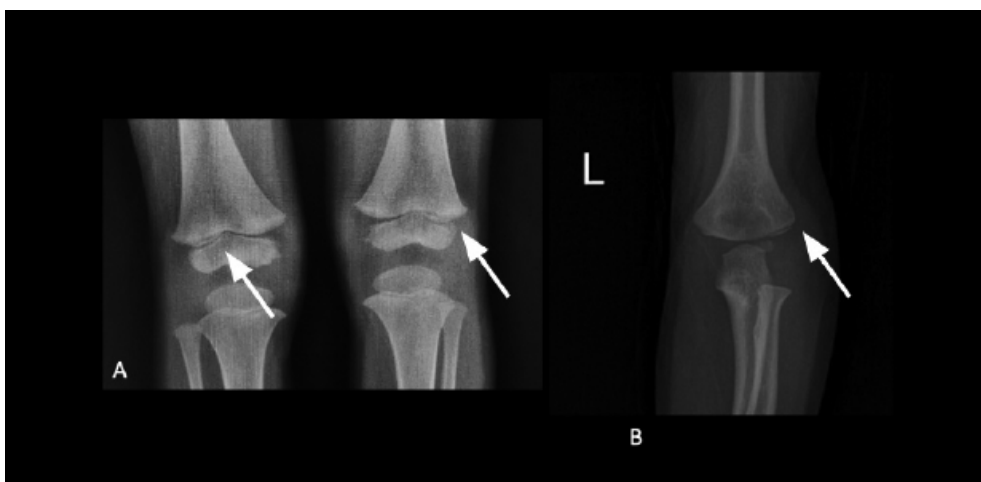
and digital fractures.⁸

Although the most frequent fractures in child victims of abuse are diaphyseal fractures of long bones, these have been described as having a low specificity for abuse, like clavicle fractures, linear skull fractures, and subperiosteal bone neoformations. It is worth noting that these lesions should be considered in the context of the child’s age, medical history, the correlation between the lesion and the data obtained, and the presence of other lesions.⁸

In relation to skull and brain injuries as a consequence of physical abuse, they usually result from 2 main mechanisms: they may be due to direct impact on the skull—which causes skull fracture traces and adjacent brain injuries—or due to a shaking mechanism, characterized by causing diffusely distributed subdural hematomas and parenchymal lesions.¹³ This last shaking mechanism, that has already been described in association with paravertebral rib fractures, also makes it necessary to perform a fundus of the eye to screen for retinal hemorrhage.¹²

Finally, abdominal injuries include perforation of intestinal loops, duodenal or jejunal hematoma, liver, splenic, and pancreatic lacerations. Although these are not specific to lesions from abuse, they have been reported as the second leading cause of mortality in child abuse.³ In general, the mechanisms of injury involve direct blows to the abdomen or abrupt deceleration force and are more frequently found in children who walk.¹⁴

FIGURE 2. Metaphyseal fractures



Frontal X-ray of both knees and left elbow. Metaphyseal fractures described as “bucket handle” (arrows), distal to the femora (A) and distal to the humerus (B).

FIGURE 3. Brain lesions

Computed tomography scan of the brain without contrast, axial images. A: Subdural hematoma (arrow) with midline displacement. B: Subarachnoid hemorrhage (arrow).

Although an abdominal ultrasound is the first test to be performed when abuse is suspected in the case of abdominal injuries, a CT scan of the abdomen with intravenous contrast is the indicated test.³

DIFFERENTIAL DIAGNOSES

It is important to mention some particular characteristics of bone development and variants of normality that may mimic injuries due to maltreatment. For example, the most confusing images include a physiological periosteal reaction of long bones, which is very marked in some infants, the persistence of the metopic suture, the squamous suture, the occipital synchondrosis, and the sternal ossification centers.¹⁵

There are also pathological conditions with lesions similar to those associated with child abuse: metaphyseal alterations characteristic of osteogenesis imperfecta, rickets, syphilis, and bone dysplasias; subperiosteal bone formation in Caffey's disease, leukemia, and osteomyelitis; intracranial subdural hematomas in the context of dystocia.¹⁵

Most of these conditions can be identified after a comprehensive assessment, a thorough patient history taking, and a detailed imaging evaluation.

CONCLUSIONS

Fractures are the second most common injury detected in children who are victims of physical abuse. In children under 2 years of age, bone lesions may be clinically silent; therefore, the recommendation is to perform an initial screening using skeletal X-rays; in the case of children under 1 year of age, a computed tomography of the brain should also be indicated.

Children and adolescents victims of maltreatment require a multidisciplinary approach. The lack of correlation between the lesions and the caregivers' account of what happened should alert pediatricians, who will work together with pediatric radiologists in order to recognize bone lesions, especially those with greater specificity for physical abuse. Working together will also allow to make a comprehensive assessment and thus rule out other differential diagnoses.

The health care team is legally responsible for detecting situations of child abuse and for reporting them to the corresponding authorities. Failure to do so could have serious or fatal consequences in these children. ■

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