The Journal of Chulabhorn Royal Academy
eISSN : 2697-5203 (Online)
Research article

Imaging Findings in Physical Child Abuse

Tanadul Jarrusrojwuttikul[1], Teerasak Phewplung[2]

[1]*Faculty of Health Science Technology, HRH Princess Chulabhorn College of Medical Science, Chulabhorn Royal Academy*
[2]*Department of Radiology, Faculty of Medicine, Chulalongkorn University, King Chulalongkorn Memorial Hospital*

*Corresponding Author e-Mail: Tanada.wu@gmail.com

Abstract

Purpose: This study was performed to demonstrate the imaging findings associated with the infliction of physical injuries in children.

Materials and methods: This study involved children who had been diagnosed with physical abuse in King Chulalongkorn Memorial Hospital from 1 January 2006 to 31 December 2015. These children's radiologic images were obtained from the hospital's Picture Archiving and Communication System and retrospectively reviewed.

Results: Twenty-five physically abused children ranging in age from 0 days to 10 years were identified. Thirteen children were boys and 12 were girls. Nineteen (76.0%) children were ≤2 years of age. The most common radiologic abnormality in our patient series was head injury, which was found in 12 (48.0%) of the 25 physically abused children. The most common feature of inflicted head injury was a subdural hematoma, which was found in eight children. Skull fractures were found in three children. Fractures of the long bones and ribs were found in six children.

Conclusion: Head injury, including skull fractures, was the most common radiologic abnormality in our study. Long bone fractures were the most common skeletal fractures, followed by skull and rib fractures. A thorough radiologic skeletal survey plays a very important role in the diagnosis of inflicted injuries in children.

Keywords: Child maltreatment, Classic metaphyseal lesion, Inflicted injury, Physical child abuse

Introduction

Child maltreatment is a worldwide occult problem consisting of neglect as well as physical, sexual, and emotional abuse. It can lead to many physical and mental health problems, including violence, depression, and alcohol and drug use. Among cases of child maltreatment, neglect is far more common than physical abuse. The prevalence rates of physical abuse reportedly range from 10.0% to 30.3% of all cases of child maltreatment in the East Asia and Pacific region[1].

The first mention of child abuse was by the French forensic physician Ambrose Tardieu in 1860. Bruises are the most common injury caused by physical abuse of children, and fractures are the second most common[2,3]. In 1946, the American pediatric radiologist John Caffey described long bone fractures and subdural hematomas (SDHs) in infants as inflicted injuries.

Later, in 1957, he also proposed the metaphy seal fracture as the most specific injury in cases of child abuse[4]. Most fractures are easily detected by imaging, which is an important examination modality in the investigation of child abuse[5,6].

Early detection of child abuse can lead to prompt intervention, decreasing the possibility of further violence and health and social problems.

The present study was performed to explore the common radiological findings in physically abused children and thus assist physicians in identifying imaging abnormalities in such cases.

Materials and methods

This retrospective study was approved by the institutional review board, and the requirement for consent was waived. The study involved children at King Chulalongkorn Memorial Hospital (KCMH) who had sustained physical abuse from 1 January 2006 to 31 December 2015 as confirmed by the Suspected Child Abuse and Neglect (SCAN) multidisciplinary team. The children's radiographic images [obtained from the hospital's Picture Archiving and Communication System (PACS)] and medical records were retrospectively reviewed.

Children whose images could not be obtained from the PACS system were excluded. Children who had sustained neglect, emotional abuse, or sexual abuse without evidence of physical abuse were also excluded. The radiographic data included plain radiography, ultrasonography, computed tomography, magnetic resonance imaging, and nuclear scintigraphy. Sex, age, physical examination abnormalities, and imaging abnormalities were recorded.

Results

The SCAN team at KCMH confirmed 45 diagnoses of physical child abuse from 1 January 2006 to 31 December 2015. Twenty children were excluded because no radiographic information could be obtained from the PACS system. Therefore, this case series included 25 children ranging in age from 0 days to 10 years (Table 1). Thirteen children were boys and 12 were girls. Nineteen (76.0%) children were ≤2 years of age. The radiographic investigations among the 25 children comprised 15 cases of brain computed tomography, 3 cases of brain magnetic resonance imaging, 1 case of brain ultrasound, and 19 cases of plain radiographs. Among the children aged ≤2 years, complete radiographic skeletal surveys were performed in three (15.8%) children.

Sixteen (64.0%) of the 25 children had positive imaging results. Head injury diagnosed by imaging was found in 12 (48.0%) of the 25 children. Three children had skull fractures, all of which were linear skull fractures. Ten children had intracranial hemorrhage, including an epidural hematoma in one, SDH in eight (Fig. 1), and subarachnoid hemorrhage (SAH) in one. One of the children with an SDH had a concurrent linear skull fracture.

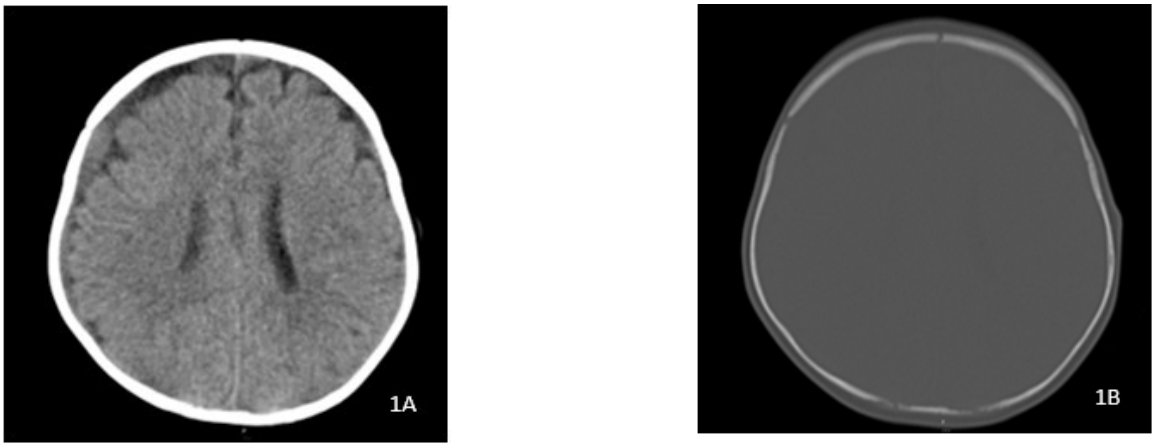

Figure 1. Non-contrast computed tomography of the brain in a 4-month-old boy. (A) A subdural hematoma is present along the right frontoparietal convexity. (B) No demonstrable skull fracture is present.

Long bone fractures were found in five children, including spiral diaphyseal fractures in three and metaphyseal fractures in two. A classic metaphyseal lesion (CML) was found in one child (Fig. 2). Rib fractures (two contiguous lateral rib fractures) were found in one child. No spine injuries were found in our case series.

Retinal hemorrhage was found in 3 (25.0%) of 12 children who underwent a fundoscopic examination. In two of these children, the retinal hemorrhage was accompanied by intracranial hemorrhage.

Figure 2. Radiograph of the right femur of a 1-month-old abused infant. A metaphyseal lucency is present across the medial half of the proximal tibia with sclerosis (arrow), representing a classic metaphyseal lesion.

Table 1. Case series of physically abused children

No.	Age	Sex	MCL	RH	Skeletal				CNS				
					long bone	rib	spine	CML	Skull	EDH	SDH	SAH	cerebral Contusion
1	3 mo	f	N/A	√	N/A	N/A	N/A	N/A	-	-	√	-	-
2	8 yr	m	N/A	-		-	-		N/A	N/A	N/A	N/A	N/A
3	6 yr	m	√	-	N/A	-	-	N/A	N/A	N/A	N/A	N/A	N/A
4	4 mo	m	√	-	N/A	-	-	N/A	N/A	N/A	N/A	N/A	N/A
5	3 mo	f	N/A	N/A	N/A	√	-	N/A	-	-	√	-	-
6	1 yr	m	√	-	-	-	-	N/A	√	-	-	-	-
7	2 mo	f	-	N/A	N/A	N/A	N/A	N/A	-	-	√	-	-
8	3 yr	m	√	N/A	N/A	N/A	N/A	N/A	-	-	√	-	-
9	1 yr	m	√	-	N/A	N/A	N/A	N/A	-	-	-	-	-
10	1 day	f	√	N/A	N/A	N/A	N/A	N/A	-	√	-	-	-
11	10 yr	f	-	N/A	N/A	-	-	N/A	N/A	N/A	N/A	N/A	N/A
12	2 yr	m	√	N/A	N/A	-	-	N/A	-	-	-	-	√
13	1 yr	f	√	-	-	-	-	-	N/A	N/A	N/A	N/A	N/A
14	1 mo	f	√	N/A	√	-	-	√	-	-	√	-	-
15	2 yr	f	√	√	N/A	-	-	N/A	-	-	√	-	-
16	3 yr	f	√	N/A	√	-	-	-	-	N/A	N/A	N/A	N/A
17	3 mo	m	N/A	N/A	N/A	-	-	N/A	-	-	√	-	√

Mucocutaneous lesions were found in 14 (77.8%) of 18 children who had physical examination records. The lesions were ecchymoses, bruises, abrasions, and second-degree burns. Seven (50.0%) of 14 children also had radiological abnormalities.

Discussion

Head injury was the most common radiological abnormality in the present case series, found in 12 (48.0%) of 25 physically abused children. This finding is consistent with that of a prior study in our institute, in which the incidence of head injury was about 83%[7]. However, the incidence was higher than that in a study by Bruce and Zimmerman[8] (approximately 12%). This discrepancy may be associated with differences in socioeconomic and cultural factors between Thais and Americans. Eleven (91.7%) of the 12 children with head injury in the present study were ≤2 years of age. SDH and SAH are commonly found in patients with inflicted brain injuries and may result from the shearing of bridging veins under the rotational acceleration theory[9]. Nine children in this study had either SDH or SAH. One such case was accompanied by rib fractures, and another one coincided with a CML. These findings imply that the children may have been injured by violent shaking. The CML, first described by Caffey[10] in 1957 and reviewed by Kleinman et al.[11] in 1986, is a highly specific feature of inflicted injury; it results from microfractures across the metaphysis perpendicular to the long bone axis and commonly occurs in the distal femur, distal tibia, and proximal humerus. Depending on the radiographic projection, degree of peripheral bony involvement, and size and degree of periosteal stripping, CMLs can be seen as a corner fracture, bucket handle lesion, or simply a metaphyseal lucency[11-13], as in the present case series. These heterogeneous presentations may affect physicians' ability to detect CMLs. Rib fractures are also considered to be correlated with physical abuse and often result from tightly holding around the chest, placing a squeezing force on the immature skeleton[12]. Abuse-induced rib fractures can occur in any aspect of the ribcage and were found in the lateral aspect in the present case series. However, posterior rib fractures are strongly specific to physical abuse[14].

The prevalence of skeletal fractures varies among physically abused children, ranging from 11% to 55%, and most fractures occur in the long bones[4]. This is consistent with the findings in our case series, in which fractures were found in 10 (40.0%) of 25 physically abused children, most commonly in the long bones but not specific except the mentioned CML. Hence, high awareness of the physician and the history provided by the parent are very important in such cases.

According to the American College of Radiology Appropriateness Criteria® on Suspected Physical Abuse–Child, a skeletal survey is always indicated in a child ≤2 years of age[15]. In the present study, however, a complete skeletal survey was performed in only 3 (15.8%) of 19 children aged ≤2 years. Such a low rate may cause problems in the diagnosis of physical abuse. This information will encourage physicians dealing with suspected abuse to perform a complete skeletal survey because early detection can lead to prompt intervention, decreasing the possibility of further violence and health and social problems.

Continuous study of the imaging patterns of child abuse will help to obtain an updated incidence of the radiographic findings that imply the mechanisms underlying abuse-induced injuries.

Conclusion

Head injury was the most common radiologic abnormality of physically abused children in our study, whereas long bone fractures were the most common skeletal fractures, followed by skull and rib fractures. A radiologic skeletal survey along with a thorough physical examination and patient history play a very important role in the diagnosis of inflicted injuries in children. Thus, radiologists should have knowledge about the imaging findings in cases of physical child abuse and collaborate with a multidisciplinary

team to ensure early detection and prevention of further injuries.

Conflict of interest statement

The authors have no conflicts of interest to declare.

Acknowledgment

The authors are very appreciative of the cooperation by the SCAN team at KCMH. The authors also thank all the staff in the radiologic department for their help in this study. Finally, the authors thank Angela Morben, DVM, ELS, from Edanz (http://www.edanz.com/ac) for editing a draft of this manuscript.

References

1. Fry D. Child maltreatment: prevalence, incidence and consequences in the East Asia and Pacific region. Bangkok: UNICEF EAPRO; 2012. https://www.pure.ed.ac.uk/ws/portalfiles/portal/10949528/K201218.pdf
2. Loder RT, Feinberg JR. Orthopaedic injuries in children with nonaccidental trauma: demographics and incidence from the 2000 kids' inpatient database. *J Pediatr Orthop*. 2007;27(4):421-426.
3. Perez-Rossello JM. The AAP and the SPR Child Abuse Committee issue a clinical report on 'Evaluating children with fractures for child physical abuse'. *Pediatr Radiol*. 2014;44(3):243.
4. Lonergan GJ, Baker AM, Morey MK, Boos SC. From the archives of the AFIP. Child abuse: radiologic-pathologic correlation. *Radiographics*. 2003;23(4):811-845.
5. Offiah A, van Rijn RR, Perez-Rossello JM, Kleinman PK. Skeletal imaging of child abuse (non-accidental injury). *Pediatr Radiol*. 2009;39(5):461-470.
6. Carty H. Non-accidental injury: a review of the radiology. *Eur Radiol*. 1997;7(9):1365-1376.
7. ปานฤทัย ตรีนวรัตน์, พัธนี โอเจริญ. ความผิดปกติจากภาพทางรังสีวิทยาของผู้ป่วยเด็กถูกทารุณกรรมที่ตรวจพบในโรงพยาบาลจุฬาลงกรณ์. *J Med Assoc Thai*. 2004;87(9):175
8. Bruce DA, Zimmerman RA. Shaken impact syndrome. *Pediatr Ann*. 1989;18(8):482-484, 486-489, 492-494.
9. Zhang L, Yang KH, King AI. Biomechanics of neurotrauma. *Neurol Res*. 2001;23(2-3): 144-156.
10. Caffey J. Some traumatic lesions in growing bones other than fractures and dislocations: clinical and radiological features: The Mackenzie Davidson Memorial Lecture. *Br J Radiol*. 1957;30(353):225-238.
11. Kleinman PK, Marks SC, Blackbourne B. The metaphyseal lesion in abused infants: a radio logic-histopathologic study. *AJR Am J Roentgenol*. 1986;146(5):895-905.
12. Flaherty EG, Perez-Rossello JM, Levine MA, Hennrikus WL. Evaluating children with fractures for child physical abuse. *Pediatrics*. 2014;133(2):477-489.
13. Paddock, M, Sprigg, A, Offiah, AC. Imaging and reporting considerations for suspected physical abuse (non-accidental injury) in infants and young children. Part 1: initial considerations and appendicular skeleton. *Clin Radiol*. 2017;72(3):179-188.
14. Feldman KW, Brewer DK. Child abuse, cardiopulmonary resuscitation, and rib fractures. *Pediatrics*. 1984;73(3):339-342.
15. Sandra L, Bruno P, Adina L. ACR Appropriateness Criteria® Suspected Physical Abuse-Child. *J Am Coll Radiol*. 2017;14(5S):S338-349.

License, Supplymentary Material and Copyright

Citation

Jarrusrojwuttikul T, Phewplung T. Imaging finding in Physical Child Abuse. *J Chulabhorn Royal Acad.* 2022; 4(1): 41-46.

Online Access

https://he02.tci-thaijo.org/index.php/jcra/article/view/252176/