Original Article

Neuroimaging of Subdural Findings with Traumatic Brain Injury in Children

Muhammad Amin, Mahwish Zahra, Umaima Majeed, Sahar Javed, Amena Maqsood and Manal Ashraf

ABSTRACT

Objective: To assess the frequency of findings (Neuroimaging and Neurological) in children with traumatic brain injury.

Study Design: A longitudinal study

Place and Duration of Study: This study was conducted at the Neurology & Radiology Department in Children Hospital & Institute of Child Health Multan from July 2020 to December 2020.

Materials and Methods: Children from 3 months to 7 years hospitalized for traumatic brain injury were included in the study. The CT/MRI scans of the participants were collected and reviewed by radiologists who were blind to the study. Neuroimaging findings like skull fracture, parenchymal involvement, extra axial collection, hygroma and soft tissue swelling were ruled out. Among neurological aspects seizures, hemiparesis and cranial nerve abnormality were reported if present. Based on medical records/history the children were grouped under the category of inflicted and non-inflicted traumatic brain injury.

Results: The neuroimaging findings were analyzed for both groups. "Inflicted Traumatic brain injury" group was quite young at the time of injury as compared to non-inflicted group ($p<0.001$). Subdural hematomas were ruled out in only 1 child among inflicted traumatic brain injury patients. However, 25% of the patients among non-inflicted traumatic brain injury group patients were diagnosed to have Epidural hematomas ($p<0.04$)" Parenchymal involvement, intracerebral hematomas" were present in 35% of the non-inflicted Traumatic brain injury group and 10% of the inflicted traumatic brain injury group ($p<0.04$). Cerebral atrophy was diagnosed on CT/MRI scan of 40% children among inflicted Traumatic brain injury ($p<0.004$). Shear injury on the contrary was only found associated with 20% of the non-inflicted Traumatic brain injury group ($p<0.04$). Subdural hygromas were visualized among 20% of children in inflicted Traumatic brain injury and only 5% in non-inflicted Traumatic brain injury.

Conclusion: A high frequency of subdural findings on neuroimaging is associated with inflicted traumatic injury in children.

Key Words: Neuroimaging, Neurological, Traumatic brain injury, Non-Traumatic brain injury, Hematomas

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INTRODUCTION

Traumatic brain injury (TBI) is one of the most common and potentially devastating neurologic disorders. It affects millions each year "resulting in over 50000 deaths and more than 70,000 patients suffer from permanent neurological deficits". Therefore, Traumatic brain injury (TBI) is a major public health problem[1].

Department of Radiology, Children Hospital & Institute of Child Health, Multan.

Correspondence: Muhammad Amin, Assistant Professor of Radiology, Children Hospital & Institute of Child Health, Multan.
Contact No: 0300-732600
Email: dramin327@gmail.com

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Inflicted TBI can be defined as non-penetrating or penetrating injury and it is an acquired brain injury. Non inflicted TBI causes damage to the brain by internal factors, such as a lack of oxygen, exposure to toxins, pressure from a tumor, etc. "TBI occurs in 12% of cases of physical child abuse". Among these, the majority of children are less than 2 years of age. According to an epidemiologic study of TBI, an assault was the cause of injury externally [2] It manifested "in 56% of the cases of serious brain injury in children less than 1 year of age". Although the assault was the cause of "only 5% of TBI in children ages 1 to 4 years, assault caused 90% of serious brain injury" [3].

TBI also accounts for a health care budget of up to 10% and also causes an estimated annual cost to society. TBI sequelae can significantly get altered by prompt proper management especially during the first 48 h following injury [4]. Neuroimaging techniques can indicate the presence and can rule out the extent of the injury. Based on the results, guidance on surgical planning can be obtained[5]. It can also be inferred from the neuroimaging that either it is possible to use minimally invasive interventions as acute therapy to manage TBI [6]. Neuroimaging can also be reliable in the chronic therapy of TBI. It allows to identify chronic sequelae, determines prognosis, and also provides a guide for rehabilitation [7]. All head injuries do not require neuroimaging. Neuroimaging is expensive and can consume the scanner time unnecessarily. It is however difficult to define minor head injuries versus major head injuries [8]. Certain situations suggest major injury and require imaging such as in cases with reduced level or loss of consciousness for more than 5 minutes, seizures, failure of improvement in mental status, confusion, aggression, or penetrating skull injuries [9].

Biomechanical forces that are produced during injury are different in "inflicted & non inflicted TBI". Injuries impact arise from "contact and inertial forces". Contact forces are mostly associated with the head traumas that result in focal injuries to the brain [10]. For example, "lacerations, fractures, contusions, and epidural hematomas". Inertial forces on the other hand "acceleration – deceleration forces" causing more diffused injuries "such as concussion, subdural hematoma, and diffuse axonal injury". In young children, the "acceleration-deceleration forces" occur frequently in inflicted TBI as compared to non-inflicted TBI[11]. The different biomechanical forces yield characteristics inflicted and non-inflicted TBI [12]. In the current study, we did a comparative analysis of acute CT/MRI findings, physical findings along with initial developmental outcomes in children. The comparison was used to analyze whether inflicted TBI is associated with a higher rate of subdural findings on neuroimaging than non-inflicted TBI. Here by the current study was to characterize neuroimaging findings with traumatic brain injury in children.

MATERIALS AND METHODS

Physical findings were analyzed in 40 children between ages 3 months to 7 years at the time of injury. The developmental status was also evaluated of these children as they were admitted from 01 July 2020 to 01 December 2020 at Neurology & Radiology Department to the Neurology Department of Children Hospital & Institute of Child Health Multan. After being affected with either inflicted or non- inflicted TBI. It was a cross sectional study design. The inclusion criteria were comprised of intermediate to severe TBI with no known history of neurologic injury, no metabolic disorder, and gestation age of a minimum of 32 weeks. Patient with any metabolic disorder and pre mature birth on history were excluded from the study. All enrolled children underwent a proper physical examination by a pediatrician. After taking informed consent from parents the study was observed during the hospitalization. The study was conducted as per the ethical guidelines. "CT/MRI scans" of the patients were obtained at the hospital and were reviewed by a consultant radiologist. The radiologist was blind to the cause of injury. The scans done within one week of the injury were considered.

Medical records were taken into consideration to check out the presence of "ocular injury, bruises, fractures", or any neurological findings. The division of children among inflicted and the non-inflicted group was done based on the history including the type, severity, and pattern of injury.

Data Analysis: "Chi-square test" was applied to estimate the distribution of normal and abnormal CT/MRI and physical findings in "inflicted & non inflicted TBI groups". A P-value of <0.05 was considered significant.

RESULTS

Demographic and history variables for both groups showed the participants were from all three socioeconomic backgrounds. Among TBI groups, more male participants were present than females. Inflicted injuries occur mostly during infancy, in accordance to that "inflicted TBI group" was quite younger at the time of injury in comparison to "non-inflicted group" (p<0.001). Some associated complications are also indicated in Table I. The neuroimaging findings are categorized and depicted in Table II. Extra axial collections were found to be present in all children in "inflicted TBI" group and also in the "non-inflicted TBI" (p<0.04). Subdural hematomas were found more associated with inflicted TBI.

Table No.1: Neuroimaging Findings from Acute CT/MRI Scans

Neuroimaging Findings	Group "Inflicted TBI" (n=20)	Group "Non-inflicted TBI" (n=20)
Soft tissue swelling		
Present	12 (60%)	17 (85%)
Absent	8 (40%)	3 (15%)
Skull fracture		
Present	9 (45%)	16 ((80%)
Absent	11 (55%)	4 (20%)
Extraaxial collection		
Hematoma	15 (75%)	10 (50%)
Subdural	1 (5%)	5 (25%)
Epidural	5 (25%)	5 (25%)
Subarchnoid		
Hygroma		
Subdural	4 (20%)	1 (5%)
Parenchymal involvement	6 (30%)	7 (35%)
Edema/infarction	2 (10%)	7 (35%)
Hematoma	3 (15%)	2 (10%)
Diffuse swelling	8 (40%)	0
Atrophy	0	5 (25%)
Shear injury		

Table No.2: Neurological Findings in inflicted and Noninflicted TBI Groups

Neurological Findings	Group "Inflicted TBI" (n=20)	Group "Non-inflicted TBI" (n=20)
Seizure	14 (70%)	2 (10%)
Hemiparesis	6 (30%)	11 (55%)
Cranial nerve abnormality	8 (40%)	7 (35%)

Epidural hematomas were ruled out in only 1 child among inflicted TBI patients. However, 25% of the patients among non-inflicted TB group patients were diagnosed to have Epidural hematomas (p<0.04).

Subarachnoid hemorrhage was present in an equal ratio among inflicted and non-inflicted TBI groups. In the context of "parenchymal involvement, intracerebral hematomas" were seen in 35% of the "non-inflicted TBI group" and 10% of the inflicted TBI group (p<0.04). The edema/infarct was found to be distributed comparably across the groups. Cerebral atrophy was characterized as proof of preexisting brain injury. Cerebral atrophy was diagnosed on CT/MRI scan of 40% children among inflicted TBI (p<0.004). Shear injury on the contrary was only found associated with 20% of the non-inflicted TBI group (p<0.04). Subdural hygromas were visualized among 20% of children in inflicted TBI and only 5% in non-inflicted TBI. Skull fractures & soft tissue swelling was reported in a comparable ratio among both groups with no significant difference.

DISCUSSION

Traumatic brain injury (TBI) in children had a different pattern of results on neuroimaging and physical findings [13]. The study determined comparatively the presence of subdural & other findings on neuroimaging of two groups of children with TBI. Despite having no history of any brain injury there was a sign of cerebral atrophy in children with inflicted TBI. Subdural hematomas were more frequently visualized in children with inflicted TBI however, the children in the "non-inflicted'' group who were found to have subdural hematomas had a history of motor vehicle accidents rather than fall or crush injuries. Epidural hematomas and shear injuries were abundantly seen in non-inflicted TBI. In the context of intraparenchymal hemorrhages, it was analyzed that both groups are affected in the same way. The details of the physical examination of these patients showed poor neurobehavioral and motor outcomes. The presence of skull fractures and soft tissue damage goes in accordance with the "shaking-impact mechanism of injury" [14]. No association was found between skull fracture and soft tissue. Likewise, no link was found between parenchymal involvement and hemorrhage. The age difference between the two groups was compared. Although the inflicted injury is correlated with infancy, however, the age distribution of non-inflicted injury was found to be constant during infancy and pre-school years [15].

More longitudinal design studies are required to find details about neuropsychologic deficiencies in children with inflicted and non-inflicted TBI either injured during infancy and pre-school years [16]. Clinical evaluations in children can be sometimes misleading for example significant parenchymal injury can be ruled out in children "with spontaneous eye opening and spontaneous movements" [17]. Besides this, based on primitive motor patterns, the infants may also show the ability to withdraw from painful stimuli when applied to limbs. Furthermore, the consciousness levels could also be misleading to assess especially in infants [18]. Therefore, the neuroimaging findings play a vital role in providing a comprehensive insight into the severity of injury in infants. Most of the time children with inflicted TBI are difficult to diagnose because of the lack in the accuracy of the provided history. In such situations, physicians must be vigilant to find out the aspects of injury that can aid in precise diagnosis and detection of the underlying cause of injury [19]. Hereby in all these scenarios where the history being provided by guardians is unreliable and unrealistic the neuroimaging techniques play a particularly important role. The cases that more specifically need neuroimaging techniques are the ones without trace of external injury [9] These types of injuries are the shaking impact injuries that result in lethal consequences with no evidence of external injury [20]. Skeletal surveys can also add valuable information to aid in suspicions of "inflicted injury". Due to the poor developmental outcomes associated with traumatic brain injury in children with similar indices of the severity of trauma [15]. It is important to identify the cause (that can be abusive) followed by neuropsychologic assessment to initiate rehabilitation and family intervention. Neuroimaging also aids in proving clues for cases involving abused brain injury [21]. It is important to correlate neuroimaging findings with "neuropsychologic evaluations and rehabilitation services". Based on the diagnosis the follow-up should be done. The effects of early brain injury become more evident with time [22]. Sequential evaluations are required to determine the rate at which the children are developing new skills. In this way, it is possible to identify potentially deficient areas that require intervention, either it needs to ensure "referral for rehabilitation or to monitor & family environment" [23]. Much literature on the neuroimaging of subdural findings in TBI is based on secondary approach. A little primary research has been done in this area.

There are some limitations to the study in context of sample size. More extended study duration with increased number of cases can provide more insightful results.

CONCLUSION

A high frequency of subdural findings on neuroimaging is associated with inflicted traumatic injury in children.

Author's Contribution:

Concept & Design of Study:	Muhammad Amin
Drafting:	Mahwish Zahra, Umaima Majeed
Data Analysis:	Sahar Javed, Amena Maqsood, Manal Ashraf
Revisiting Critically:	Muhammad Amin, Mahwish Zahra
Final Approval of version:	Muhammad Amin

Conflict of Interest: The study has no conflict of interest to declare by any author.

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