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Originals

Craniocerebral trauma in the child abuse syndrome: radiological observations

D. F. Merten[1], D. R. S. Osborne[1], M. A. Radkowski[2] and J. C. Leonidas[3]

Departments of Radiology, [1]Duke University Medical Center, Durham, North Carolina, [2]University of Chicago-Wyler Children's Hospital, Chicago, Illinois, and [3]Tufts New England Medical Center, Boston, Massachusetts, USA

Abstract. Experience with craniocerebral trauma in 712 physically abused children is reviewed. Ninety-three (13%) had evidence of head trauma (cranial and/or intracranial). Seventy-seven of these patients had computed tomography (CT) of the head, and 47 had CT evidence of intracranial injury. Extracerebral fluid collections, predominantly convexity subdural hemorrhage, were the most common acute intracranial lesions. Concurrent intracranial and skeletal trauma (cranial and/or ectracranial) was present in 33 of the 47 patients (70%) with intracranial injury. A high incidence of skull fractures (45%) in those children with intracranial lesions suggest a significant role for impact head injuries ("battering") in the pathogenesis of craniocerebral trauma in the child abuse syndrome. Greater emphasis on CT examination in evaluation of the abuse infant and child is recommended.

Head injury has been recognized as a major cause of morbidity and mortality since the earliest descriptions of the child abuse syndrome [1, 10, 18]. Until recently, however, radiological evaluation of craniocerebral trauma in child abuse victims has been limited. The advent of cranial computed tomography (CT) added an important diagnostic dimension to evaluation of intracranial lesions [7] and focused attention on the scope and severity of head injuries in the child abuse syndrome [19, 23].

In order to further define the incidence, pattern and pathogenesis of craniocerebral trauma in the child abuse syndrome, the combined experience with physically abused children from three medical centers (Duke University Medical Center, University of Chicago-Wyler Children's Hospital, Tufts-New England Medical Center) has been reviewed [13] with emphasis on the pathologic pattern of intracranial injuries, and associated skeletal trauma, both cranial and extracranial.

Materials and methods

Clinical data from 716 infants and children with physical evidence of abuse admitted to three medical centers was reviewed [13]. Skull radiography was obtained as part of a complete skeletal survey (skull, thorax, spine, extremities) in 512 of these patients. Head CT examination was performed in 77 patients with clinical and/or neurologic evidence of head trauma. The nature and localization of the cranial and intracranial lesions were determined by standard CT criteria [5, 6, 12, 22, 24], and tabulated as to age – acute or non acute (chronic). Skeletal trauma including both cranial and extracranial injuries was also tabulated, and correlated with intracranial lesions.

Radiologic evidence of craniocerebral trauma, cranial and/or intracranial, was present in 93 patients. Their age ranged from 2 weeks to 11.5 years (mean 12 months); 90% were less than 2 years of age. Sex ratio was 50 male/43 female. A history of trauma, variable in type and severity, was obtained in 82 cases. Neurologic symptoms include seizures in 22, disturbed consciousness in 19, and developmental or mental delay in 11. Failure to thrive was the presenting complaint in 11. Signs of craniocerebral trauma included cutaneous evidence of facial and head injury in 83 cases; disturbed sensorium in 23, and increased intracranial pressure in 13. Retinal hemorrhage was described in only 10 cases. Other generalized evidence of physical trauma included cutaneous injury in 67 and extremity disuse and/or deformity in 23. In addition to clinical signs of physical abuse, 26 had evidence of neglect. Ten patients died acutely.

Results

Cranial trauma

Skull fractures were present in 67 of the 93 patients. Fifty-nine (88%) had simple linear fractures, most commonly parieto-occipital in location. Depressed,

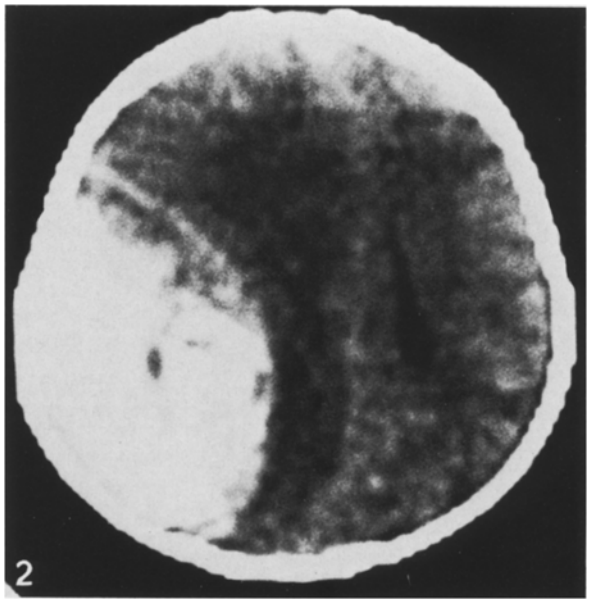


Fig. 2. Acute epidural hemorrhage. 5-month-old infant: progressive lethargy following "minor" head injury; multiple cutaneous injuries were associated with skull fracture. Unenhanced CT: large convex left parietal epidural hematoma associated with predominantly unilateral cerebral edema and ventricular shift to the right. The infant died

Fig. 1. Acute subdural hemorrhage. 2-month-old infant: seizures and cutaneous injuries with skull and extremity fractures. Unenhanced CT: right posterior frontal convexity hematoma (hollow arrow) associated with posterior occipito-parietal interhemispheric hematoma (solid arrow)

comminuted and diastatic fractures were uncommon. Skull fractures were associated with intracranial trauma in 21 patients (56%).

Intracranial trauma (Table 1)

Extracerebral, cerebral, and ventricular intracranial abnormalities, isolated or in combination, were identified with initial CT examination in 47 of the 77 patients. The lesions were judged to be acute in 36 cases; while in 11 they appeared to be non-acute or chronic, presumably post-traumatic residual lesions. Concurrent acute and non-acute or chronic lesions were observed in 1 patient.

Acute. Extracerebral fluid collections were present in 26 of the 36 patients (72%) with acute injuries. Subdural hematomas were the most common acute extracerebral collection (23/26–89%) (Fig. 1). Convexity lesions were more common (16 versus 11) than central interhemispheric collections. Convexity subdural hematomas were concurrent with interhemi-

Table 1. Intracranial trauma (47 patients)

	Patients			
	Acute	36	Chronic	11
Extra cerebral		26		9
	Subdural hemorrhage	23	Subdural hygroma	9
	Convexity	16	Convexity	9
	Interhemispheric	11	Interhemispheric	8
	Subarachnoid hemorrhage	9		
	Epidural hemorrhage	2		
Cerebral		26		2
	Diffuse cerebral edema	24	Focal encephalomalacia	1
	Contusion – hematoma	10	Generalized atrophy	1
Ventricular		2		9
	Intraventricular hemorrhage	2	Ventriculomegaly	9
			Porencephaly	1

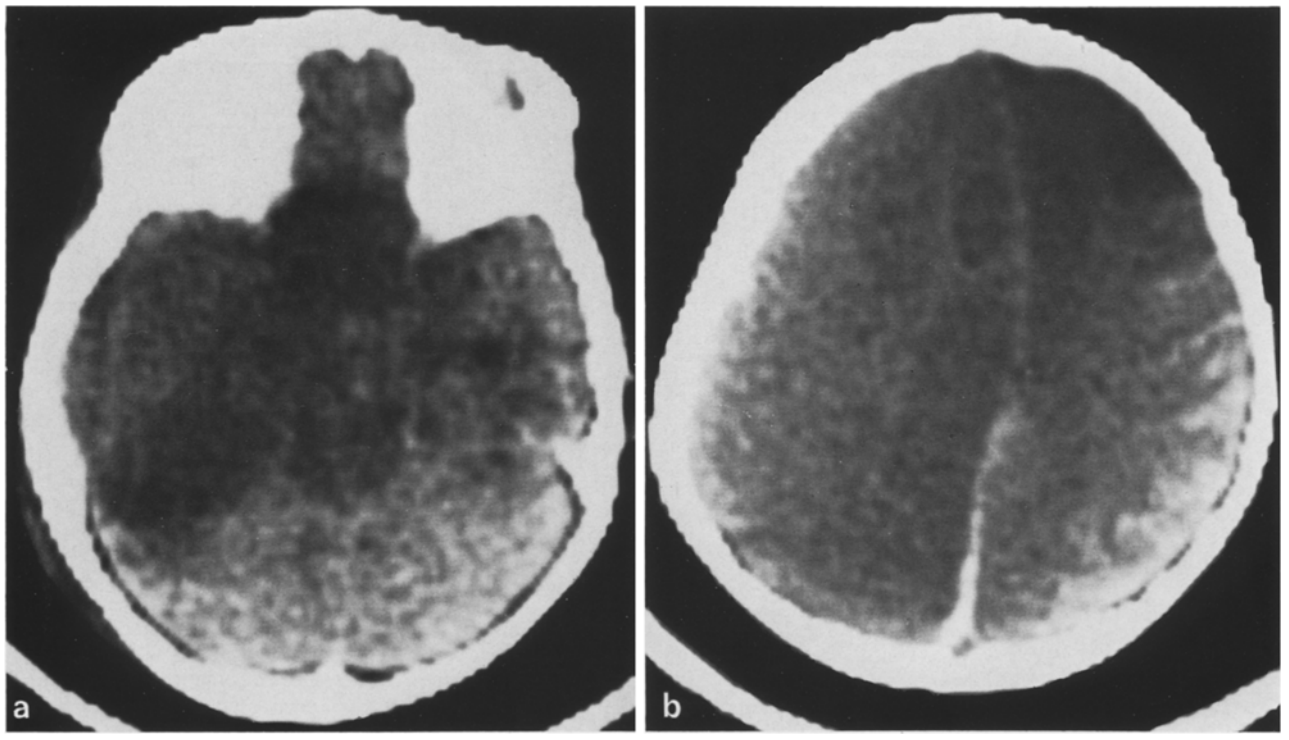


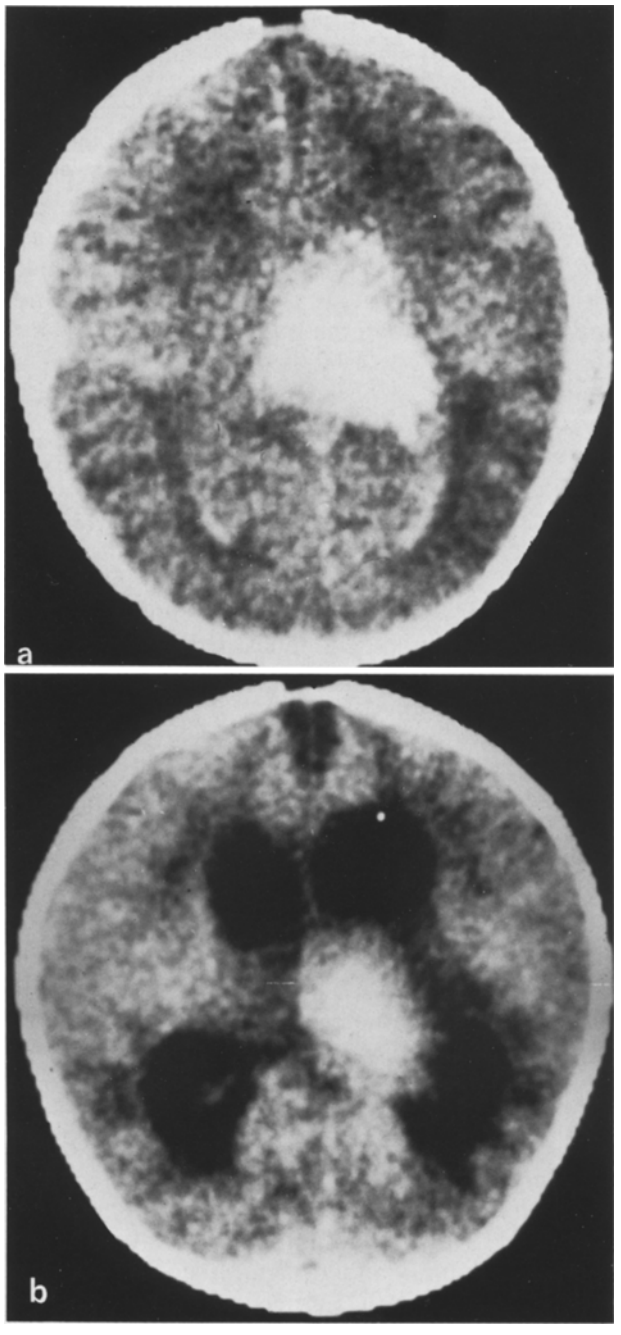
Fig. 3 a and b. Acute cerebral infarction. 22-month-old infant: decreasing consciousness following head injury. A cephalohematoma was associated with extensive cutaneous injuries. There were no skeletal injuries. Unenhanced CT: marked right shift and extensive bilateral low density consistent with cerebral edema and infarction. The infant died: post-mortem examination confirmed cerebral infarction

spheric collections in 4 cases. Subarachnoid hemorrhage was observed in 9 cases and epidural hematoma in 2 cases (Fig. 2). Cerebral lesions, both focal and diffuse, were identified in 26 patients. Diffuse edema, unilateral and/or bilateral in 24 cases was the most common (24/26–92%) cerebral lesion. Diffuse edema was present in association with an extracerebral hemorrhagic collection in 12 cases (Fig. 2). In 4 patients extensive cerebral edema suggested brain death: the presence of edema and extensive cerebral infarction were subsequently confirmed at post-mortem examination. Focal cerebral infarction was present in 2 cases (Fig. 3). Focal superficial and/or deep intracerebral contusion-hemorrhage was present in 10 patients (Fig. 4). Acute intraventricular hemorrhage was present in 2 cases.

Follow-up CT examination in 22 of the 26 patients who survived acute injuries revealed residual intracranial sequelae in 16.

Chronic. Eleven patients had evidence of a non-acute or chronic posttraumatic lesion on the initial CT examination. Extracerebral fluid collections, specifically chronic subdural collections were observed in 9 cases. Convexity collections were usually conjoint with interhemispheric collections. Focal encephalomalacia (Fig. 5) was noted in 1 case. Ventriculomegaly, usually associated with subdural collections, was frequently present in the 11 patients.

In all, 33 of the 47 (70%) patients with intracranial injuries had at least 1 skeletal injury. In this group, skull fractures were present in 21 and other extracranial fractures were present in 25: both skull and extracranial fractures were present in 13. At least 1 fracture was clinically unsuspected (occult). Multiple skeletal fractures were present in 18 and concurrent acute and healing fractures indicative of repetitive episodes of abuse were present in 11 of the 47 with CT evidence of intracranial injury. Only 4 patients with intracranial lesions had epiphyseal-metaphyseal fractures considered "typical" of the battered child syndrome [3, 11]: all four had additional foci of skeletal injury (skull 3, ribs 1). One or more foci of skeletal trauma were present in 25 of the 36 patients (69%) with acute intracranial lesions. Skeletal trauma was present in 7 of the 11 (67%) patients with non-acute or chronic intracranial lesions noted on initial CT. All had extracranial fractures; while skull fractures were present in only 2 of these patients.



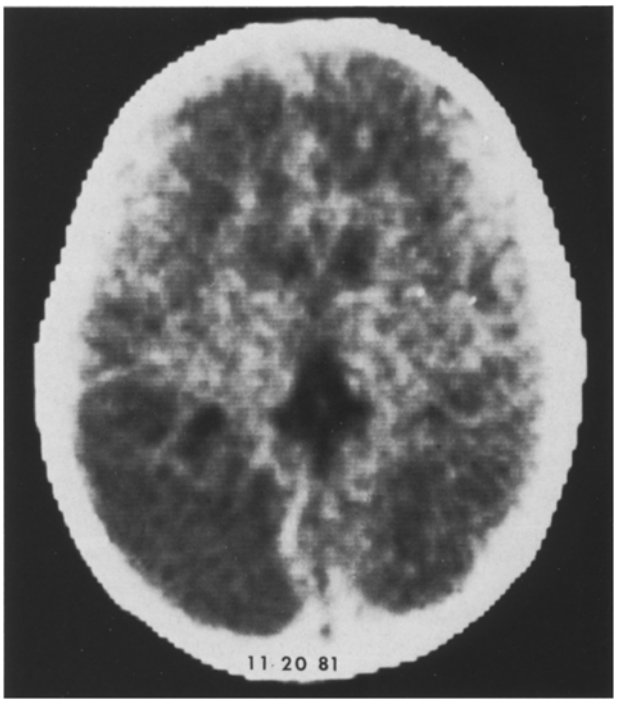


Fig. 5. Chronic encephalopathy (encephalomalacia). 2-month-old infant: seizure and loss of consciousness following injury. There were multiple cutaneous injuries and retinal hemorrhages with skull and rib fractures. Initial CT examination (10-17-81) demonstrated diffuse cerebral edema and bilateral posterior superficial cerebral contusion-hemorrhage. Unenhanced CT (11-20-81): 1 month later bilateral extensive but predominantly posterior reduction in attenuation consistent with encephalomalacia. The child had severe mental and motor retardation

Fig. 4 a and b. Acute cerebral contusion-hemorrhage. 1-month-old infant: multiple cranial and facial ecchymoses, cephalohematoma without known head injury. **a** Unenhanced CT (10-25-81): focally increased callosal density consistent with deep shearing injury. Additional hemorrhage was present in the right thalamus. Right parietal skull fracture with contra-coup superficial contusion-hemorrhage was also demonstrated. **b** Unenhanced CT (11-16-81). Follow-up CT 3 weeks later demonstrates striking ventriculomegaly and paraventricular hypodensity consistent with obstructive hydrocephalus. There is residual callosal and thalamic hematoma

Discussion

Our experience with craniocerebral trauma, associated with child abuse differs from previous reports in both the frequency of head injury and the pathologic pattern of intracranial injury.

The reported incidence of craniocerebral trauma, and more specifically intracranial injury, varies widely and appears to be dependent on the size and make-up of study groups. Tsai and associates found intracranial injury in 19% of 177 "battered children" [19]; O'Neil et al reported intracranial injuries in 29% of 110 abuse victims [15]; while Oliver described "severe and irreparable damage to the brain and central nervous system" in 44% of 38 patients [14]. Approaching the problem from another direction, Zimmerman found that 10% of acute head injuries were associated with child abuse [24]. Our results, based on a large (716) and unselected group of physically abused children covering a broad spectrum of severi-

ty suggests the overall incidence of craniocerebral trauma is approximately 13%, and that the incidence of intracranial injury is 7%. These figures, however, may understate the true incidence of the intracranial sequelae of abuse since CT was performed in only 77 patients, and long-term follow-up was not available in the majority of cases. Subtle acute and chronic post-traumatic sequelae may therefore have been missed. Despite these shortcomings, however, we believe that the results of the present study represent a reasonably accurate, although probably conservative, estimate of the incidence of craniocerebral trauma and more specifically intracranial trauma in the child abuse syndrome.

Pathologically the frequency and pattern of specific intracranial injuries, and the association of cranial and extracranial skeletal injuries, differed from those described by Zimmerman [24]. Interhemispheric subdural hemorrhage was the most common intracranial lesion in his series and was found with six times the frequency of convexity hematomas (12/2). By comparison, in our experience interhemispheric lesions were less common than convexity lesions (11/16). We also found the incidence of localized intracerebral contusion-hemorrhage to be greater: 21% (10/47) versus 8% (2/26). Perhaps the most striking difference in radiological findings between the two studies was the frequency of concurrent skeletal trauma in patients with intracranial injuries. Of the 22 patients with acute intracranial lesions in Zimmerman's series, none had extracranial trauma and only 4 (18%) had skull fractures. In our experience, however, cranial and/or extracranial skeletal trauma was present in 70% of cases with intracranial lesions. Skull fractures were associated with acute intracranial lesions in 45% of our patients. The findings of the present study are more in line with those of Tsai [19] who found skull fractures in 45% of his patients with acute intracranial injuries.

The increased incidence of associated skeletal trauma, cranial as well as extracranial, suggest a greater role for physical "battering" in the pathogenesis of craniocerebral and more specifically intracranial injuries in the abused child. Craniocerebral trauma in the abused infant and child may be due to direct beating and/or shaking during the course of abuse [3]. The concept of the "shaken child" was originally proposed by Caffey [2] and further delineated by Guthkelch [8]. They suggested that sudden acceleration-deceleration of the head (whiplash) associated with violent shaking produced shearing laceration of bridging cerebral veins, most marked at their attachment to the venous sinuses (falx). The result was most commonly central or interhemispheric subdural hemorrhage. We should emphasize, however, that identical forces and stress are produced during the course of impact injuries such as the rapidly moving head striking a stable object or vice versa [9]. The beaten or battered child has been reported to have a greater incidence of skull fracture associated with CT evidence of contusion, intracranial hematomas, and peripheral (convexity) subdural hematomas; while the shaken child has a greater incidence of central, interhemispheric subdural hemorrhage with relatively infrequent association of skull fractures [24]. Based upon the frequency of central subdural hemorrhage as well as the paucity of skeletal trauma observed in his series, Zimmerman emphasized the role of whiplash induced (non-impact acceleration/deceleration) intracranial injuries in the abused infant and child. Our results suggest that there may have been an over-emphasis on "shaking" in the pathogenesis of abuse-related intracranial injury. Both "shaking" and "battering" no doubt occur as isolated or associated events in many victims of abuse. It is important to emphasize that the presence or absence of evidence of "battering" should not preclude consideration of child abuse when the nature and severity of intracranial injuries suggest non-accidental trauma.

Despite Caffey's early admonition that the presence of unexplained skeletal lesions in abused children warrants investigation for intracranial lesion [3] discussion of radiological evaluation in general texts dealing with child abuse either fail to describe the role of CT in the evaluation of the abused child [4, 14] or give the subject only cursory attention [17, 21]. In light of the importance and severity of both acute craniocerebral trauma and chronic neurologic sequelae associated with the child abuse syndrome [20], it is surprising that the role of cranial CT in evaluation of the abused child has not received greater consideration. We concur with Roussey [16] and Zimmerman [24] that CT examinations should be performed in any abused infant or child with extensive physical injury and/or neurologic findings suggesting post-traumatic intracranial sequelae. As a corollary CT evidence of residual unexplained, possibly post-traumatic lesions in infants and children must provoke consideration of possible child abuse.

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Dr. D. F. Merten
Department of Radiology
Box 3834
Duke University Medical Center
Durham, North Carolina 27710
USA

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