

Abraham Jacobi Award Address

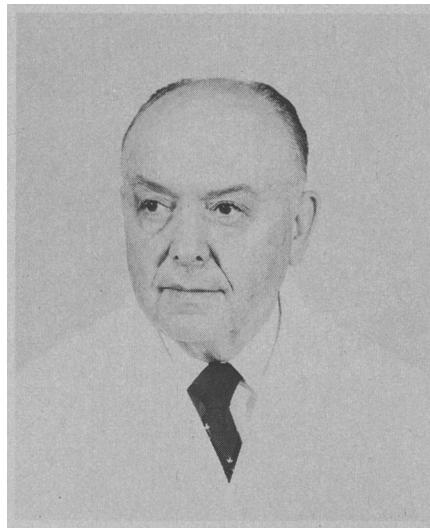
On the Theory and Practice of Shaking Infants

Its Potential Residual Effects
of Permanent Brain Damage and Mental Retardation

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In the first modern discussion in 1946 of the parent-infant stress syndrome (PITS), or battered baby syndrome, I described six infants, 13 months or younger, who suffered from the combination of subdural hematomas and characteristic bone lesions.¹ During the last 25 years²⁻⁵ substantial evidence, both manifest and circumstantial, has gradually accumulated which suggests that the whiplash-shaking and jerking of abused infants are common causes of the skeletal as well as the cerebro-vascular lesions; the latter is the most serious acute complication and by far the most common cause of early death.⁶

Today we invite your attention to the evidence which supports our concept that the whiplash-shaking and jerking of infants are frequently pathogenic and often result in grave permanent damage to infantile brains and eyes. We shall also point out that potentially pathogenic whip-



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lash-shaking is practiced commonly in a wide variety of ways, under a wide variety of circumstances, by a wide variety of persons, for a wide variety of reasons. The most common motive for repeated whiplash-shaking of infants and young children is to correct minor misbehavior. Such shakings are generally considered innocuous by both parents and physicians. If our concept of the pathogenic significance of whiplash-shaking is valid, it follows that the prevention of such shaking and jerking might substantially reduce the incidence of brain damage and mental retardation. The

line of demarcation between pathogenic and nonpathogenic shaking is often vague.

The nature and distribution of the bone lesions in the PITS must be interpreted from the radiographic changes exclusively because they have not been studied systematically at either surgical exploration or necropsy. The metaphyseal avulsions are the most common of these lesions. Some are small fragments of cortical bone torn off the external edge of the cortical wall at the metaphyseal levels where the periosteum is most tightly bound down to the cortex. In most cases, however, they appear to be small chunks of calcified cartilage which have been broken off the edges of the provisional zones of calcification at or near the sites of the attachments of the articular capsules (Fig 1 to 3). Often bones on both the proximal and distal sides of a single joint are affected, especially at the knee. All of these metaphyseal avulsion fragments appear to result from *indirect, traction, stretching, and shearing, acceleration-deceleration stresses on the periosteum and articular capsules*, rather than *direct, impact stresses such as smashing blows on the bone itself*.

Traumatic involucra (Fig 4 to 6) commonly accompany the metaphyseal avulsions and involve the same terminal segment of the same shaft.

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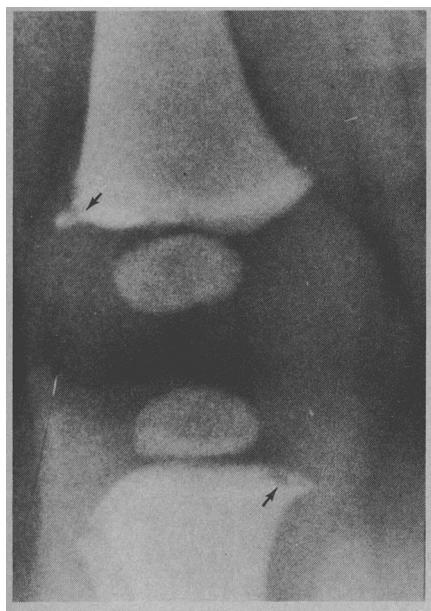


Fig 1.—Unexplained metaphyseal fragments (arrows) of the provisional zone of calcification (pzc) on the proximal side of the knee in the femur and the distal side of the knee in the tibia of a patient 4 months of age whose parents denied trauma.

They are the largest and most conspicuous of all traumatic lesions in growing bones. Usually they are not fracture-dependent. They develop due to traction-rupture of the abundant normal perforating blood vessels, which course through the cortical wall between the periosteum and the medullary cavity and which are severed at the junction of the internal edge of the periosteum with the external edge of the cortex. The accumulation of blood internal to the periosteum, but external to the cortical wall, lifts the periosteum off the wall for variable distances and forms subperiosteal hematomas of variable sizes and shapes. Often these are symmetrical in analogous bones in the two arms or legs, or they affect bones in the arms and forearms only, or sometimes in the thighs and shanks only. Frequently they involve bones on both the distal and proximal sides of a single joint, especially the knees. At first they appear radiographically

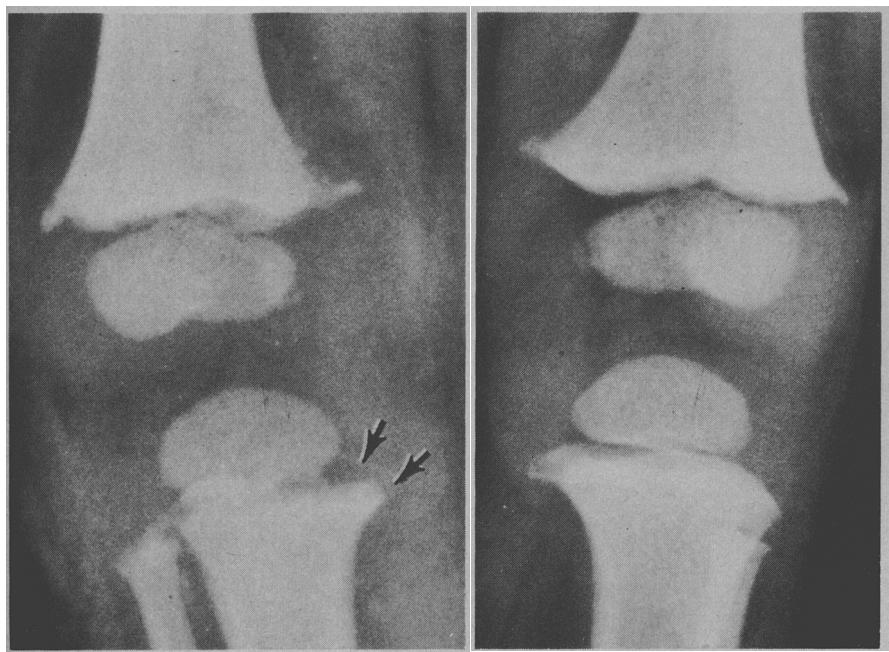
as masses of water density superimposed on the shaft, but after four to ten days a thin opaque shell of new fibrous bone begins to form around the external edge of the hematoma. The entrapped subperiosteal blood is then gradually resorbed. The nature and distribution of these lesions can be best explained on the basis of *indirect, primary, acceleration-deceleration traction drags* on the periosteum, its vessels, and the joint capsules from manual seizing and gripping the extremities and whiplash-shaking the head. Neither their nature nor their distribution can be satisfactorily explained on the basis of *direct impact stresses (blows)* on the bone itself.

Several observers have noted associated diffuse sclerosis of the shafts of some of the affected bones of some abused infants. This has suggested excessively fragile, brittle, chalk-like bones to some radiologists. In recent biopsies, however, the microscopic examination disclosed the lamellae to be laid down in an irregular woven pattern. This, in my opinion, indicates that the sclerosis is caused by excessive newly formed primitive fibrous or woven bone, which forms regularly under the periosteum following traumatic subperiosteal edema or bleeding or both. Traumatic thickenings of the external subperiosteal edge of the cortical wall are the cause of the sclerosis. The epiphyseal ossification centers and round bones are not sclerotic. These sclerotic shafts are probably stronger than normal shafts.

Traumatic metaphyseal cupping is due to traumatic obstructive injury to the epiphyseal arterioles in the neighboring cartilage plate¹; and the metaphyseal "loop" deformities² are due to stretching and extension of the traumatic involucra terminally. Both of these lesions are best explained on the causal basis of the grabbing, squeezing the extremities by the assailant's hands, and whiplash-shaking the infant's head.

Despite the failure of parents and physicians to appreciate the grave significance of whiplash-shaking younger infants, and to record shaking in medical histories, there are

Fig 2.—Symmetrical metaphyseal "angle" fragments in the edges of the pzc of both femurs with fragments in the medial edges of the tibial pzc. A faint "loop" deformity, a fine opaque curved line (arrows), is superimposed on the epiphysis of the right tibia.



several convincing recorded examples of pathogenic and even fatal shaking.

EXAMPLE 1 (15 CASES).—The most gruesome and, at the same time, the most significant examples of proved pathogenic whiplash-shakings and of burpings are recounted in the story of an infant-nurse (*Newsweek* 48(pt 1):90, 1956). She is reported to have killed three infants and maimed 12 others during a period of eight years, largely by shaking and jolting infantile brains and their blood vessels. These assaults all occurred in the homes of upper-middle-class, well-educated, well-to-do parents, who provided expert medical care by highly trained pediatricians. Her services were said to have been much in demand because she had built up a reputation for being "extravagantly kind" to her infant charges. Both parents and doctors apparently had full confidence in her; in one instance she was invited back by the parents to care for their second infant after she had shaken their first child to death. After one infant was found dead without satisfactory explanation, the nurse explained that she had only tried to get the bubble up. "I picked him up and tried to get the bubble up. I didn't do anything wrong." After another of her patients had succumbed unexpectedly, she admitted that she "had given him a good shaking." Necropsy disclosed traumatic brain injury. Eventually she admitted killing three infants and maiming two others. When these admissions became known to the community, parents disclosed that ten additional infants had been significantly injured by this nurse.

The primary assaulting force in all of the nurse's attacks on infants appears to have been violent whiplash-shaking and excessive whiplash-pounding on the back during burping. One is amazed that she was able to continue her murderous assaults in this much better-than-average social and medical milieu for eight years. It is likely that she did not realize the full power and violence generated in her shaking of small infants. She weighed 105.32 kg (233 lb) and was said to have had very large hands. The last infant she shook to death weighed 4.97 kg (11 lb). Had the nurse been shaken by a caretaker of corresponding weight and strength, the monster would have weighed 21 times her weight or about 2,226 kg (5,000 lb) and would have had the strength of 21 strong women.

EXAMPLE 2 (FOUR CASES).—Weston⁶ and Steele and Pollock⁷ report four cases of pathogenic shaking in battered babies. (1) A girl, 2½ years old, was shaken violently

because she whined. (2) A girl 4 years of age was shaken violently because of incessant crying. (3) A girl 4 months of age was shaken fatally, during which her head was banged against the crib. (4) A girl, 2 years old, was shaken and beaten to death with a stick.

EXAMPLE 3 (THREE CASES).—A boy of 6 months had unexplained convulsions and fever. His mother was too shocked to speak. A subdural hematoma was excised and he died three days later. Eventually the mother admitted that she had shaken him several times to save him from "choking to death" during a violent paroxysm of coughing. She had attempted to "clear his throat" and he went into convulsions following the shaking. (2) A boy, 6 months old, began to vomit and convulse. There were no external signs of head injury but retinal hemorrhages were seen in both ocular fundi. Subdural hematomas were treated surgically. (3) A few days later, this patient's twin brother came to the hospital with an unexplained broken femur. Shortly thereafter, the first twin returned with persistent subdural hematoma. By this time, bruises had appeared on both his forearms, which fitted the pads in the fingers and thumbs of the examiner's hands, where the boy's forearms had been gripped by his assailant during the shaking. Eventually, the mother admitted that she and her husband "might have shaken him when he cried at night." Guthkelch opines that a "good shaking" is felt by British parents to be more socially acceptable, and physically less dangerous, than blows or punches to the head.

EXAMPLE 4 (ONE CASE).—Kempe et al⁸ described radiographic bone lesions caused by the repeated parental shaking of a prematurely born twin girl of 7 months, who had been abused by the mother since the second month of life. She was shaken while gripped by the legs and held inverted. Multiple massive involucra and several metaphyseal avulsions developed in her femurs and tibias.

EXAMPLE 5 (ONE CASE).—Swischuk¹⁰ described compression fractures of vertebral bodies in one infant, which were believed to be due to whiplash-shaking.

EXAMPLE 6 (THREE CASES).—We have found two examples of protective jerking and one of repeated sibling whiplash-shaking. We have encountered two patients in whom a single, sudden, violent jerk of one extremity apparently produced metaphyseal avulsions and traumatic involucra. (1) A boy, 4½ months old, had always been well until his mother grabbed him by one forearm and yanked him upward to pre-



Fig 3.—Unexplained traumatic fracture fragments at both ends of pzc (angle fractures) of the left femur with fine, thin, external thickenings of its cortex which represent early traumatic involucrum. Two thicker, older, traumatic involucra have formed in the distal thirds of the two tibial shafts; these lesions indicate that the infant (6 months) had been seized by both ankles.

vent his falling to the floor, off a bassinet. Six weeks later, massive involucra of the radius and ulna in the seized forearm were demonstrated radiographically. (2) A girl of 3 weeks was said to have suddenly developed unexplained swelling of the knee and fever. Twelve hours later, a pediatrician diagnosed osteomyelitis of the tibia because of point tenderness at the knee and slight fever and leukocytosis. There were no bruises. Treatment with penicillin was begun. Radiographs showed avulsion fracture fragments at the level of one proximal tibial metaphysis which indicated trauma. Later films showed the evolution of a long traumatic involucrum on this tibia, when the fever was subsiding. On the 19th day, the mother admitted that, just prior to the appearance of the swelling of the knee, she had grabbed the baby by the leg and jerked her upward to protect her from falling onto a hard wood floor. At the same time she had fallen forward with her and onto her. The pediatrician was still reluctant to accept the primary diagnosis of a trauma because he was unfamiliar with the frequency of fever and leukocytosis after traumatic internal hemorrhage.¹¹ (3) This boy of 8 months had had



Fig 4.—Unexplained massive traumatic involucra of the left humerus of an infant 13 months of age whose parents denied traumatic abuse. The external edges of the new cortical shell are uneven and there are large and small blackish patches which indicate uneven resorption of blood or repeated traumatic episodes with recurrent subperiosteal bleeding.



Fig 5.—Unexplained large centrally placed traumatic involucra on the anterolateral aspects of the left humerus of a boy 13 months of age whose parents denied traumatic abuse. This arm had been wrapped in a bandage which bound him in restraint during the performance of a cerebral angiogram, eight weeks earlier.

unexplained swellings and tenderness and limitation of motion in both legs for several weeks when radiographs of the skeleton disclosed traumatic involucra at the proximal ends of both femurs. The parents rejected the diagnosis of trauma because, other than themselves, no one had been alone with the infant except his 8-year-old brother. He, however, had frequently acted as a lone babysitter when the parents went out socially. They found, at the first trial, by secretly watching their son as lone babysitter, that soon after their departure

he seized the infant by the legs and shook him violently, and swung him, and flung him onto a bed.

EXAMPLE 7 (Two CASES).—These cases involve oculovascular lesions. Gilkes¹² mentions the case of Wallis in which subdural hematoma and retinal hemorrhages resulted from seizing an infant by the legs and swinging him in a circle about the parent's head. He also refers to Breinin's infant patient who developed retinal lesions after a parent had gripped him by the thorax and shaken him violently.

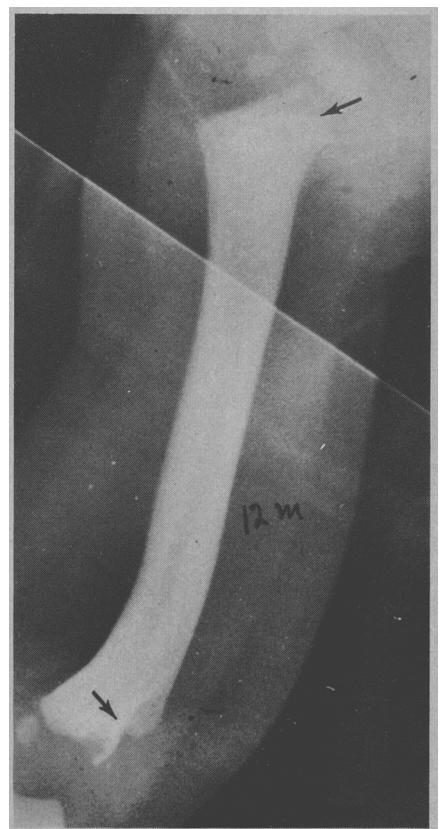


Fig 6.—Metaphyseal avulsion at the proximal and distal ends of the humeral shaft of a boy 12 months old. The distal third of the shaft is thickened and sclerotic due to an old and fused traumatic involucrum. The parents denied physical injury.

These 27 examples of recorded pathogenic shaking represents only an infinitesimal portion of the uncounted thousands of moderate unadmitted undetected and unrecorded whiplash-shakings which probably occur every day in the United States. The actual daily incidence of pathogenic shakings in the United States is unknown, but it is undoubtedly substantial. The admitted pathogenic whiplash-shakings by the infant-

nurse, cited above, have a special relevance because they demonstrate conclusively that even repeated murderous whiplash-shakings can be concealed for years without arousing the suspicions of educated parents and well-trained pediatricians, in an optimal medical and socioeconomic environment. This long concealment was due in large part to the fact that shakings, which caused fatal brain damage and intracranial bleedings in the nurse's patients, did not cause suggestive signs of head injury such as bruising of the scalp and face, or cephalhematoma, or bulging of the anterior fontanel, or fractures of the calvarium.

The whiplash-shaking of infants and younger children are precarious, pervasive, prevalent, and pernicious practices which can be observed wherever parents, parent-substitutes, infants, and small children congregate: in the home, on the street, in buses, nurseries, kindergartens, day-care centers, orphanages, "preschool" schools, in parks, playgrounds, shopping centers, and even in the waiting rooms of pediatric clinics. Many well-intentioned, responsible parents, who think nothing of giving a small child a "good shaking" or a series of such shakings, would not dream of giving their child a series of "good" blows or punches on the head. Yet, the cumulative pathogenic effects of repeated mild or moderate whiplash-shakings of the head, though inapparent clinically, may be far more grave than single, even if heavy, blows or punches to the head. The history of trauma and the nature of the traumatic force used cannot usually be elicited, sometimes owing to traumatic amnesia of the perpetrators who may not remember the traumatic episode or the kind and amount of violence inflicted on the infant. Steele and Pollock call this kind of amnesia "more or less unconscious defensive forgetting."

The grabbing and gripping of an infant or younger child by the extremities or by one leg or arm and then shaking him seem to be instinctive, almost reflex, violent actions by

angry adults in the commission of wilful assault or for ordinary discipline of minor misbehavior. Many infants are whipped, beaten, and spanked, as well as shaken. The frequency of whiplash-shaking varies inversely with the age of the infant; apparently, many infants are shaken and jerked, but few are spanked prior to the seventh month of life. Over-vigorous pathogenic shaking may be resorted to unwittingly, by a frightened parent or nurse, to dislodge a suspected foreign body from the mouth or pharynx, or to stop violent coughing, or protracted crying and whining. Even overvigorous "burping" may be fatal, as demonstrated in the story of the shake-prone infant-nurse. All curative and prophylactic medical procedures which require repeated whiplash-shaking and jerking of the head are potentially pathogenic to the brain and should be banned or used with proper caution. Artificial respiration may induce excessively high intracranial and intraocular venous pressures which lead to hemorrhagic brain and eye damage and pneumomediastinum.

There are several apparently innocent, accepted, habitual practices, other than intentional shaking and jerking, which whiplash the head and brain, and which could lead to permanent brain damage. The infantile head is subjected to some of these stresses during such playful practices as repeated vigorous "tossing the baby into the air"; "riding the horse," in which the infant faces the parent while sitting on his pendulant shin, which is swung ventrodorsally; "cracking the whip," or gripping the infant by his ankles and swinging him in a circle around the parent's head; or spinning him on his own longitudinal axis; and "skinning the cat," in which the younger child is suddenly somersaulted forward, after being gripped by the wrists which have been inserted backward between his thighs. Infants and younger children are often handled too roughly in play by older siblings as well as parents, in such procedures as "shaking or spinning him dizzy." It

is obvious that younger, more supple, calvaria of smaller children, of 4 to 8 years, although less pliable than the calvaria of the first weeks and months, were not designed for the habitual jolting of repeatedly diving headfirst into water, waterskiing, protracted gymnastic tumbling, and the inevitable brain-jolting of such adversary sports as boxing, wrestling, football, and basketball when indulged in repeatedly for several years. In some of these, the training sessions of several hours each week are more hazardous than the games and performances themselves.

Many of the toys and recreational contraptions which generate whiplash-shakes and jolts to the head should be more carefully assayed for their pathogenicity, and banned from infantile and early juvenile use if it can be shown that their cumulative effects over protracted periods are pathogenic. These items should include baby bouncers and infant jumpers and, for younger children, the swings, seesaws, and playslides in amusement parks, the powered vibratory training and practice equipment in gymnasias; powered cradles and powered rocking horses; trampolines; skateboards, and sled jumping. The same studious consideration should be given to jolting transport-vehicles which carry infants and small children—bicycles and such powered vehicles as motorcycles and motor cars driven rapidly and habitually over rough roads. The recurrent exposure to the snowmobile probably offers the greatest hazard to infantile brains and hearing. The pathogenic, brain-jolting, whiplash potentials for infants and younger children who are carried habitually in speedboats over rough water and in small airplanes in rough weather are manifest. Noise and other vibratory stimuli may be peculiarly pathogenic to infants when they are subjected to them continuously 24 hours a day at home. Mental and emotional disorders are said to be more prevalent around airports with high noise and air-vibration levels. It is possible that the noises and air-vibrations induced by radio, television,

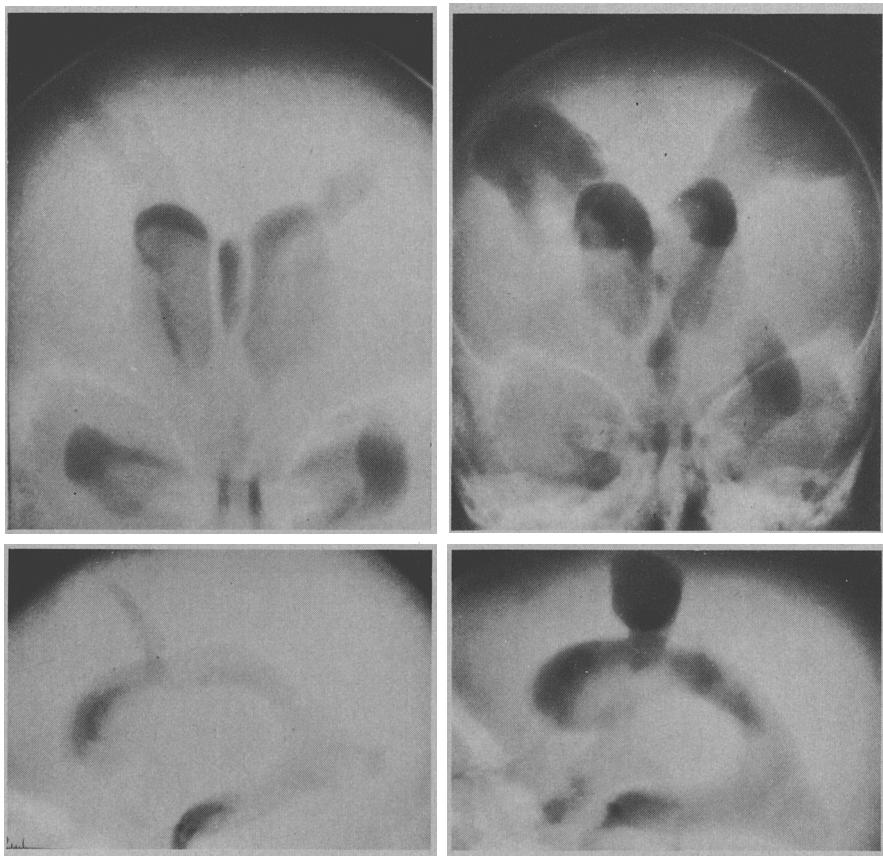


Fig 7.—Large bilateral porencephalic cavities. Top left and top right, Frontal projections at the seventh week. Bottom left and bottom right, Lateral projections two weeks later at the sites of needle tracks in the cerebral hemispheres of an infant who had suffered from meningitis at 7 weeks of age and who was subjected to "needling" of the brain to get the causal organism for optimal treatment.

amplified hi-fi sets, air-conditioners, telephones, vacuum cleaners, blenders, and garbage disposal and dish-washing units may interfere with the basic rest needs of the infant in his own home when he is overexposed to them continuously for long periods. In small thin-walled apartments, excessive exposure of an infant to pathogenically high-level noises is practically guaranteed.

Some of the more violent forms of endogenous trauma, such as the repeated convulsions in tetanus, epilepsy, or of meningoencephalitis caused by viral infections or by lead poisoning, may induce traumatic whiplash-brain damage and mental retardation. The grave, frequently fatal encephalopathy of infantile pertussis results, in part, from increased intracranial venous pressures caused by se-

vere paroxysms of coughing, which in turn leads to focal cerebral hemorrhages and residual cerebral damage. Rhythmic whiplash habits of the infant himself during the first months of life, such as *head-rolling*, *body-rocking*, and *head-banging* may be traumatically pathogenic to his brain and its veins. Protracted, repeated severe *breath-holding spells* may be similarly damaging to the brain.

Theoretically, the heads of infants who suffer disorders characterized by immaturity of their calvaria such as osteogenesis imperfecta, familial hypophosphatasemia, hypophosphatasia, lacunar skull, and cleidocranial dysostosis should all be specially vulnerable to whiplash shaking. This is also true for the infantile disorders associated with weakness of the cervical muscles.

Subdural hematomas are practically always traumatic in origin. They are found commonly in infants younger than 24 months with a peak incidence during the sixth month.¹³ This high vulnerability of the neonate and the younger infant to traumatic intracranial bleeding is due to the combination of heavy head and weak neck muscles, which renders his brain especially susceptible to whiplash stresses. Also his thin, partly membranous calvarium is supple and permits easy stretching of the brain and its veins by the postnatal indirect whiplash-traction stresses of shaking and jerking. The softness of his immature unmyelinated brain adds to its vulnerability. The actual time of onset of the subdural hematoma is usually uncertain during the first weeks and months of life. Much postnatal trauma has long been depreciated because it has been undetected and ascribed to birth injury. Premature infants are very vulnerable, and the vulnerability of full-term infants varies inversely with age. Male infants are twice as vulnerable as females; this is probably due to the relative immaturity of male heads and brains. The hydrocephalic premature infant is maximally vulnerable.

Infantile subdural hematoma frequently remains undiagnosed owing to the customary lack of distinctive diagnostic signs and symptoms. Ingraham and Matson¹³ obtained a history of birth injury in only 26% of their 319 patients, and postnatal injury in only 20%. In 54%, the source and nature of the trauma was never determined. Fractures of the skull were identified in only 9%. Regional bruises of the scalp and face were not sufficiently frequent to be included in their tables on clinical findings. The clinical picture was not characteristic; it was made up mainly of fever, convulsions, vomiting, and hyperirritability. These signs are all common to many ordinary infantile disorders. It is probable that practically all of the small cumulative subdural hematomas which result from habitual shaking remain undiagnosed permanently, and go on to become chron-

ic subdural hematomas.

Ingraham and Matson¹³ state that their mentally retarded and deficient patients, for the most part, were those who suffered from large chronic hematomas associated with marked atrophy of the cerebral hemispheres. The incidence of mental retardation in their pretreated and nontreated patients is not reported. They did find, however, that incomplete removal of the marginal membranes of the hematoma restricted the normal growth of the underlying cerebral cortex and impaired mental growth. This statement implies that the persistence of the membranes in all undetected, untreated patients would impair mental growth in a far greater number in cases of undiagnosed, untreated chronic subdural hematoma. Ford¹⁴ found cerebral damage and mental deficiency and motor deficits in a large majority of the children who survive after aspiration treatment alone. One can reasonably conclude that whiplash-shaking and jerkings, which are the prime causes of subdural hematoma in diagnosed cases, are also substantial causes of later mental retardation in the countless cases of unrecognized chronic subdural hematoma, in far greater numbers. The frequent bilaterality of subdural hematomas also supports whiplash-shaking as the probable cause.

The retinal lesions caused by shaking will undoubtedly become valuable signs in the diagnosis of subclinical inapparent chronic subdural hematoma, and also become a productive screening test for the prevalence of whiplash-dependent mental retardation and other types of so-called idiopathic brain damage. Kiffney¹⁵ found bilateral retinal detachments in a battered girl of 7 months. Maroteaux and associates¹⁶ found permanent, stable retinal lesions in the peripheries of the ocular fundi of previously battered children. In five battered children, Friendly¹⁷ found retinal hemorrhages associated with intracranial bleedings.

It should be borne in mind that the "needling" of the brain to get diag-

nostic, subdural, subarachnoid, or intraventricular fluid may in itself be a dangerous procedure¹⁸ and may lead to extensive porencephaly and brain destruction (Fig 7). Smith and Crothers¹⁹ have shown that the injection of air into the lumbar subarachnoid space may cause intracranial bleeding and intracranial subdural hematomas. Overvigorous passive movements of the infantile head—to displace the intracranial gas and place it in optimal positions for diagnosis—expose the bridging veins to additional pathogenic stresses.

Chronic infantile hydrocephalus has not been reported as a residual in the follow-up studies of abused infants but has been found in many cases of chronic subdural hematoma.¹⁴ Since subdural hematoma is a common complication of infant abuse, it is possible that residual hydrocephalus has been present but missed because it was not adequately searched for in the currently available inadequate studies of the late sequels in shaken infants. Cephalic enlargement of idiopathic hydrocephalus may not be noted until several weeks or months after birth, which raises the high probability that some, or even much, of the hydrocephalus which has been attributed to birth injury actually resulted from early postnatal whiplash-shaking. The studies of Laurie and Berne²⁰ and several others have demonstrated that subarachnoid hemorrhage is an important cause of the hydrocephalus engendered by birth injury; this may be equally true for the postnatal injuries caused by whiplash-shaking.

Russel²¹ states that the hydrocephalus-producing gliosis of the brain which follows hemorrhages is so similar microscopically to the hydrocephalus-producing gliosis which follows infections that the two cannot be satisfactorily differentiated. The obstructing subependymal gliosis which surrounds the aqueductus cerebri and causes the most common type of ventricular hydrocephalus in infants may be either infection-dependent or hemorrhage-dependent. The same is true for the neuroglial

membranes in the fourth ventricle which block the foramina of Luschka and Magendie and may cause the cystic hydrocephalus of the fourth ventricle (Dandy-Walker syndrome).

According to Russel, the meninges react similarly to several kinds of particulate matter in the spinal fluid and produce an inflammatory exudate, followed later by a localized gliosis (fibrosis). Blood extravasated into the ventricular and meningeal spaces can, thus, cause obstructions to the flow of cerebrospinal fluid and back pressure dilatations at any and all levels. Russel also cites examples of hydrocephalus due to hemorrhages incidental to brain surgery. There is, therefore, good evidence that hydrocephalus is frequently caused by intracranial hemorrhage and also good evidence that intracranial hemorrhage is a common feature of the whiplash-shaken infant. Hydrocephalus, however, has not been reported as a significant sequel of abused infants (shaken infants). More adequate late studies of large populations of previously traumatized infants are needed for a satisfactory solution of this contradiction.

Mental retardation occurred in high incidence in two small follow-up studies of abused infants. In Elmer's²² group of 22 infants, 12 had intelligence quotients of less than 80. This incidence of 12 in 22 becomes increased to 17 in 22 (77%), if one adds five more retarded children who were not available for interviews because they had already been admitted to state institutions for the mentally retarded. None of 67 nonabused children in the control group had similarly low IQs. Morse et al²³ found the incidence of mental retardation to be 60% in 15 children who had been followed for three years after the original injury. Kempe et al reported brain damage in 25 of 45 fatal cases in 1962.⁹ These high incidences in three reports suggest that permanent brain damage and mental retardation develop in a surprisingly high number of infants in whom traumatic abuse has been detected. More detailed studies of large populations with

valid controls are needed for determination of the true incidence.

Characteristic, consistent structural changes in the brain have not been demonstrated in so-called idiopathic juvenile mental retardation, which includes 80% to 90% of all cases. In the case of whiplash-shaking, cerebral injuries, it is possible that the original, early traumatic cerebral edema, the small cumulative chronic subdural hematomas, the petechial hemorrhages, and even the larger cerebral contusions have all disappeared completely by the time, years later, the brains are available for autopsy. Owing to the frequent lack of comparable degrees of structural changes in the brains of children who are severely retarded mentally, it has been suggested that the original injuries caused irreversible change in the neurons themselves—changes which are not detectable microscopically or chemically.

The cerebral lesions of whiplash-shaken children have not been studied systematically. In some studies of blunt traumatic injuries to the head, the changes in the brain have differed significantly in younger infants from those in older infants, children, and adults. Diffuse gliosis was common in the youngest brains and may have been the residual of earlier traumatic cerebral edema and hemorrhage. The authors point out that mental deficiency and motor defects may be due to the destruction of the matrix cells around the lateral ventricle.

The most striking documented clinical and pathologic example of mental deficiency, induced by repeated whiplash jolts to the head and which are associated with profuse petechial hemorrhages in the brain, is the so-called punch-drunk or slap-happy veteran fist-fighter. He develops severe losses of memory and impairments of judgment with speech and gait disturbances from being repeatedly jabbed and beaten over the head during years of exposure in the boxing ring. He may never suffer detectable acute brain injury from a single heavy blow; he does suffer, however,

from the cumulative effects of numerous, milder, repeated jabs which jolt his brain. If one cared to paraphrase the cruel but realistic lingo of the fight game, one could accurately describe some mentally retarded children as "jolt-dolts" or whiplash-silly.

The exact prevalence of idiopathic juvenile mental retardation in the general child population is not known but all responsible estimates indicate that it is woefully high—as high as 2 million cases in persons younger than 18 years.²⁴ The rate during infancy is set at 0.5% to 1%. Ten percent to 15% of children in large metropolitan centers have been classified as mentally subnormal. It is obvious that, if the whiplash-shaking of infants is even a minor cause of such a pervasive and devastating disorder, its prevention would eliminate substantial amounts of massive human suffering and misery, as well as monumental socioeconomic wastage. If one assumes that the average family unit for each retarded child includes two parents and two siblings, we can then appreciate that the lives of 8 to 10 million additional humans are dwarfed and darkened by this most baneful of all chronic human scourges—juvenile mental retardation.

Cerebral palsy and idiopathic epilepsy appear to be due to postnatal trauma in many cases, especially in those cases in which the clinical signs first appear weeks, months, and years after birth. It is probable that postnatal whiplash-shaking plays an important causal role in some or many of these patients. Neither of these disorders has yet been reported as residual effects in the PITS. More, and more comprehensive, studies are needed to determine the causal significance of whiplash injuries to the infantile brain, in residual cerebral palsies and idiopathic epilepsy.

Summary and Conclusions

Shaking is generally disregarded as a type of causal violence in the PITS by both parents and physicians and it is rarely mentioned in medical histories. Thus, both its frequency and potential pathogenicity are con-

sistently depreciated and ignored.

The radiographic bone changes in the PITS, both their nature and distribution, indicate that they are usually caused largely by rough man-handling of the infantile arms and legs, such as grabbing and then grasping, squeezing, wringing, and jerking, and then whiplash-shaking of the head; all usually occur in the absence of bruises in the skin of the arms and legs.

Several examples of pathogenic jerking of the extremities and whiplash-shaking of the head have now been recorded in the PITS; six of these were fatal.

Whiplash-shaking is widely practiced in all levels of society, by a wide variety of persons, in a wide variety of ways, for a wide variety of motives.

The pathogenicity of ordinary, casual, habitual, customary, repeated shaking of infants is generally unrecognized by physicians and parents.

The infantile head is especially vulnerable to whiplash injuries owing to a combination of the normal relatively heavy head and weak neck muscles, to the plasticity of an immature, partially membranous calvarium, and to the softness of an immature, unmyelinated brain.

Some, perhaps many, of the cerebrovascular injuries which are currently attributed, both clinically and microscopically, to prenatal infections, congenital malformations, birth injuries, and genetic metabolic diseases are undoubtedly caused by undetected, depreciated, and inapparent whiplash-shakings during the first weeks and months of life.

In the follow-up studies of two small groups of previously traumatized children, mental retardation was found to have a surprisingly high incidence. The mental status of these patients was not determined prior to their traumatic abuse.

The evidence on which our concepts of the pathogenicity of infant-shaking is based does not lend itself to satisfactory statistical analysis; "universal" samples of a total population of shaken infants have not been ob-

tained, nor have adequate matching controls of unshaken infants from the same socioeconomic milieu.

1. Whiplash-shaking of the infantile head is always potentially pathogenic to some degree. Its actual incidence is unknown and cannot be even estimated satisfactorily.

2. Whiplash-shaking appears to be practiced widely in all levels of society for many different reasons. It is generally ignored by physicians.

3. The habitual, repeated, relatively mild whiplash-shakings which are inflicted in the ordinary training and disciplining of infants, and which may induce undetected cumulative chronic subdural hematomas and other undetected chronic types of brain damage, are probably more pathogenic than the less frequent but more violent and conspicuous shakings during wilful assault, because they are consistently unrecognized and may persist to generate mental retardation and permanent brain damage.

4. There are several features of infantile subdural hematomas which indicate that they are not usually caused by direct impact injuries to the head, but are caused by indirect acceleration-deceleration traction stresses such as whiplash-shaking of the head. These features include bilaterality of subdural hematomas in 85% of infants¹³ and frequent bilateral retinal hemorrhages. There is a striking lack of such signs of impact injuries such as blows to the head. Usually there are no bruises to the face or scalp, no subperiosteal cephalhematomas, and no fractures of the calvarium.

5. There is considerable manifest and much circumstantial evidence which indicates that whiplash-shaking and jolting of infantile heads may be major, unrecognized causes of mental retardation and permanent brain damage. The wide practice of habitual whiplash-shaking for trivial reasons warrants a massive nationwide educational campaign to alert everyone responsible for the welfare of infants on its potential and actual pathogenicity.

6. Trauma is the most important killer and crippler of infants and children and it warrants aggressive study to insure effective preventive and optimal diagnoses and management. It seems certain that a new pediatric subspecialist will soon emerge, a pediatric traumatologist, who will head trauma teams in the larger medical clinics and attack the problem of traumatic diseases with the same success as other pediatric subspecialists have already achieved in the infectious, neoplasms, metabolics, deficiency, and genetically determined diseases.

The problem and the prevention of whiplash injuries are summarized in the following quatrain:

*Hark ye, good parents, to my words true
and plain,
When you are shaking your baby, you
could be bruising his brain.
So, save the limbs, the brain, even the life
of your tot;
By shaking him never; never and not.*

COMMENT.—Dr. C. Henry Kempe, University of Colorado, made available data from his new book *Helping the Battered Child and Its Family* (J. B. Lippincott Co.). In chapter 7, by Harold Martin, 42 abused children were followed for three years. He found 33% functionally retarded; 93% of these had a history of trauma to the head. Subdural hematomas or skull fractures were found in 31% and 43% had neurologic residuals. Dr. Martin points out the complexities and interfering factors in attempting to establish exactly the amount of permanent brain damage and mental retardation which results directly from traumatic abuse.

A comprehensive and authoritative biography of Abraham Jacobi by J. S. Leopold can be found in Borden Veeder's *Pediatric Profiles* (C. V. Mosby Co., 1957).

Drs. Bertram Girdany and Albert B. Ferguson generously provided much excellent radiographic and clinical material from the departments of radiology (Dr. Girdany) and orthopedic surgery (Dr. Ferguson), Children's Hospital of Pittsburgh.

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