

Fatal Abusive Head Trauma Cases

Consequence of Medical Staff Missing Milder Forms of Physical Abuse

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Objectives: Missed diagnosis of child abuse may lead to chronic abuse with potential for death. This paper reports 3 such cases.

Methods: This is a retrospective chart review of 38 cases diagnosed as abusive head trauma between January 1, 2004 and December 31, 2006 at a university hospital. We sought to identify fatal cases with a past medical history of physical abuse that was missed by the medical staff.

Results: Three cases (7.9%) had a past medical history of physical abuse that was missed by the medical staff. Infants were 2 males and 1 female. Their ages were 2.5, 3.5, and 6 months, respectively. Missed abuse episodes involved rib fractures, a metaphyseal tibial fracture, and a shaking episode, respectively. The intervals that had elapsed between the missed and the fatal abuse episodes were 24 hours, 12 days, and 6 weeks, respectively. Perpetrators of fatal head trauma were all biological fathers. One pled guilty, and 2 were convicted of involuntary manslaughter. The infants were in the care of the perpetrators of the fatal abuse episodes at the time the missed abuse episodes occurred.

Conclusions: Physicians assessing children, especially infants, should be alert to indicators of abusive trauma to recognize abuse early on. Including abusive trauma in the differential diagnostic list and taking appropriate steps to rule out or confirm the diagnosis are of paramount importance in establishing child protective services and preventing further abuse and neglect that may at times be fatal.

Key Words: abusive head trauma, missed diagnosis

Abusive head trauma (AHT) is a dangerous form of child abuse, and it is the most common cause of infant mortality and morbidity.¹ Abusive head trauma accounts for 80% of fatal or life-threatening injuries attributed to child abuse.²

In the diagnostic process, the parental history of trauma is generally understood to be a very important component in establishing the mechanisms of injury in childhood accidents and child abuse. In abusive trauma, it is widely reported that

the caretakers will provide no history of trauma, a history of low-impact trauma, or an evolving history of trauma.³⁻⁵ If a child's caretakers do not give an accurate history, making the correct diagnosis may be difficult because symptoms are often nonspecific. Vomiting, fever, irritability, and lethargy, are common symptoms of a variety of conditions seen in children including AHT. Jenny et al⁶ reported in 1999 that in 31% of 173 cases of children with AHT seen by a physician, the appropriate diagnosis was not established during the initial visit. When an abusive injury is mistakenly diagnosed as a medical illness or an accidental condition, the chronic nature of child abuse may bring the child back to medical care with either more severe forms of abuse or a fatal outcome. Thus, when dealing with injury in young children, physicians must be extremely vigilant to be able to differentiate between abusive and accidental trauma.

We reviewed the University of Iowa Child Protection Consultation Team database for the years 2004 through 2006 to determine the rate of fatal AHT cases with a history of missed abuse. Those cases with a past medical history that revealed episodes of chronic but milder forms of abuse that physicians missed during previous visits are discussed in detail to stress that missed recognition of milder forms of abuse can and do lead to fatality.

METHODS

The University of Iowa Children's Hospital Child Protection Consultation Team database was reviewed for cases with AHT who were younger than 4 years and admitted to the hospital between January 1, 2004 and December 31, 2006. Thirty-eight cases were identified. These cases were diagnosed with AHT by the hospital's Child Protection Consultation Team consisting of a child abuse specialist, a social worker, an attending physician from the pediatric intensive care unit (PICU), a pediatric neurologist/neurosurgeon, and a pediatric radiologist. In all the cases, the diagnosis was substantiated as AHT by the Child Protection Services (CPS).

To determine the rate of missed diagnosis of abusive trauma in the past medical history of the cases before their most recent admission, a retrospective review of the following records was performed: (1) electronic and paper documentation notes for the last admission, (2) local/regional multidisciplinary team meeting minutes, and (3) local medical records of previous hospitalizations or emergency department (ED) visits provided to the team by CPS. The hospital's patient's rights office approved of the report of these cases on the condition of patient anonymity.

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RESULTS

The database and chart reviews revealed that the University of Iowa Child Protection Consultation Team served 38 cases of AHT during the study period. In these cases, 5 (13.2%) had a fatal outcome and only 3 (7.9%) had normal neurological examination results on discharge; the remainder (78.9%) survived with neurological impairments. Five cases (13.2%) had a past medical history of missed diagnosis of abusive trauma before the most recent admission related to AHT. Three of these cases (7.9%) had a fatal outcome. The details of the course of child abuse in these 3 fatal cases are reported in this paper.

Case 1

A 6-month-old female infant was admitted to the hospital with status epilepticus. The past medical history was remarkable for premature delivery (29 3/7 weeks of gestation), apnea of prematurity, and respiratory distress syndrome until 52 days of age. Development was age-appropriate. She had only one set of immunizations. The infant ate approximately 6 to 8 oz of Enfamil Lipil every 4 to 5 hours.

She was in her usual state of health until 2 days before admission, when her parents noted decreased movement, pain, and swelling of her right leg. The evening before admission, she was seen at the local hospital where an x-ray of the leg was read as showing no fracture by the ED physician on call. She was discharged home with a planned visit to the orthopedics clinic the next day. That evening, the patient was extraordinarily irritable. She was in her father's care, who reported she woke up at 4:30 A.M. She took some formula and went back to sleep to wake up at 9:30 A.M., when her mother took over her care. Her mother immediately noted a cycling motion of her arms, which spread to her legs. She was rolling her eyes up and was not responsive. She was taken to the local ED where she was intubated and transferred to the university hospital after a loading dose of phenobarbital.

The Hospital Child Protection Consultation Team met with both parents at the PICU. They both denied any trauma including falls, impact to her head, shaking to revive when found unresponsive, or rolling over her while cosleeping. Nobody but the parents had access to the child.

On physical examination, weight, body length, and head circumference were at age-appropriate percentiles for corrected age. The infant was in deep coma, the anterior fontanel was bulging and tense, and the pupils were sluggishly reactive to light. She had nonspecific bruises on her left upper extremity, left thorax, and over the lower thoracic spinous prominence. The right lower extremity appeared swollen below the knee with some deformity. An ophthalmology examination revealed diffuse retinal hemorrhages in both eyes with retinal detachment in the right eye.

A full skeletal survey revealed a metaphyseal fracture on the right distal tibia that was verified by the university hospital pediatric radiologist to be present on the leg radiograph obtained at the local hospital the day before (Fig. 1). The initial head computed tomographic (CT) scan showed diffuse brain edema and evidence of diffuse hypoxic ischemic injury. The hemoglobin level was 8.5 g/dL, the aspartate aminotransferase level was 163 U/L; the alanine aminotransferase level was 104 U/L, the lactate dehydrogenase level was 569 U/L, and the coagulation profile was within normal limits. The blood culture revealed no bacterial growth. The result of the urine and hair screening for illicit drugs was negative. The urine organic acids analysis indicated mild ketonuria secondary to catabolic state.

The infant displayed a deepening coma and diabetes insipidus despite interventions. A second head CT scan revealed a worsening

diffuse hypoxic ischemic injury throughout the brain and a compression of the basal cisterns (brainstem herniation). She died because of anoxic encephalopathy with secondary brain swelling and herniation.

In addition to the previously stated findings, an autopsy revealed

- Widening of the sagittal and frontal parietal sutures with subgaleal hemorrhage
- Congested gray matter of the upper cervical spinal cord
- Acute subdural hemorrhage, multiple areas of subarachnoid hemorrhage, and vascular (ischemic) and traumatic axonal injury on staining with amyloid precursor protein
- Peripapillary, episcleral, and orbital fat hemorrhages; intradural, subdural, and subarachnoid optic nerve sheath hemorrhages; bilateral diffuse retinal hemorrhages in all layers of the retina from the posterior pole to the periphery; and an irregular macular fold in the right eye globe
- A 2 × 0.6-cm brown contusion of the proximal anterior left shin
- A focal periosteal hemorrhage of the mid diaphysis of the right tibia

Case 2

A 3.5-month-old male infant was transferred to the PICU from a local hospital with seizures and respiratory failure. He was born at 37 weeks of gestation and had an unremarkable neonatal and postneonatal course until the last incident. There was no history of bleeding disorders, metabolic disorders, or brittle bone disease. The child had a half brother from his 19-year-old mother.

Before the most recent admission, he was in the care of his father in his usual state of health. His father reported that he picked him up out of a swing, put him on the sofa, and changed his diaper while he was still asleep. During the diaper change, he reportedly lost muscle tone and became limp with apnea. His father denied observing seizures, skin color change, or vomiting. He reported doing mouth-to-mouth respiration but denied applying chest compressions. The infant was transferred to the university hospital from the local ED. The University Hospital Child Protection Consultation Team met with both parents at the PICU.

The parents reported that the infant was in his usual state of health until 2 months of age when he was observed to fall off a

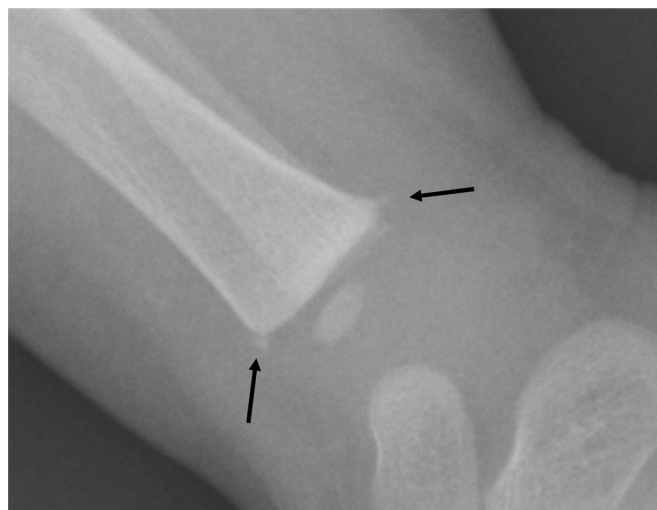


FIGURE 1. Bilateral acute metaphyseal fractures on the right distal tibia missed by the ED physician one day before nonaccidental head trauma.

couch (approximately a foot from the floor) onto the carpeted surface on his face while in the care of his father. He did not lose consciousness, but in 2 days, he developed a friction over his rib cage that was both audible and palpable to both of his parents. A chest radiograph obtained at the local ED was read by the examining physician as showing no fractures despite palpation of a crepitation over the rib cage. The parents reported that this friction lasted for a while, and the child reacted in pain when they touched his rib cage. Both parents denied any other history of trauma including rolling off a high surface, impact to the head, shaking for the purpose of reviving after the onset of seizures, or chest compressions.

On physical examination, the weight was less than 3%, the body length was at 3%, and the head circumference was at 50%. The infant was in deep coma with no active movements. The remainder of the examination results was within normal limits. Ophthalmology examination revealed bilateral diffuse retinal hemorrhages.

Coagulation studies revealed a mild coagulopathy, a prothrombin time of 15 seconds, and a partial thromboplastin time of 32 seconds. The hemoglobin level was 9.3 g/dL, the results of the urine organic acids analysis were normal, and the urine illicit drug screening was negative. A skeletal survey revealed healed old posterior fractures of the left 8th through 11th ribs, healing old lateral fractures of the left fourth and fifth ribs, healed old posterolateral fractures of the right seventh and eighth ribs, thickened pleura adjacent to lower rib fractures on the left, and acute Salter-Harris type 2 proximal-medial metaphyseal fracture of the right tibia. The chest radiograph from 6 weeks prior was read by the pediatric radiologist at the university hospital as showing acute posterior rib fractures of the eighth ribs with pleural fluid collection adjacent to the fractures (Figs. 2 and 3). An initial local head CT scan showed diffuse cerebral edema with questionable left cortical bleeding. A second head CT scan showed increasing intracranial pressure, reversal sign, and severe brain edema. Coma gradually deepened, and the child died because of brain herniation.

In addition to the previously stated findings, an autopsy revealed

- Left parietal subgaleal hemorrhage (7 × 4 cm) and midfrontal subcutaneous hemorrhage

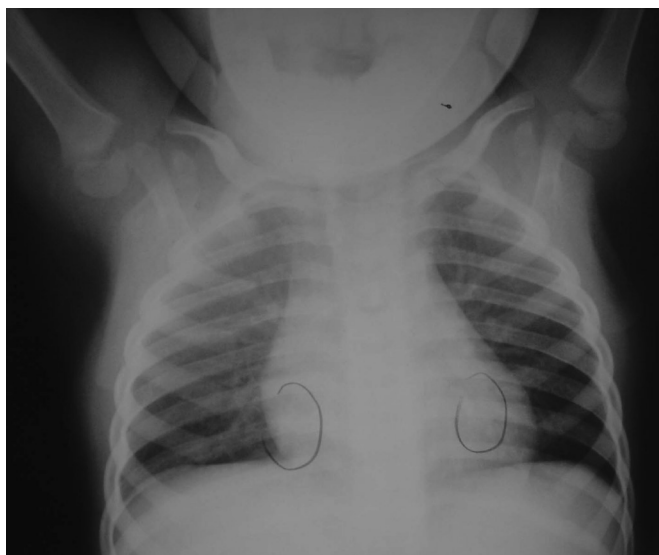


FIGURE 2. Bilateral acute posterolateral rib fractures on the eighth ribs missed by the ED physician and the radiologist 6 weeks before nonaccidental head trauma.



FIGURE 3. Acute pleural effusion on lateral view missed by the ED physician and the radiologist 6 weeks before nonaccidental head trauma.

- Three-centimeter, nondisplaced, linear fracture of the left parietal skull
- Acute subdural hematoma (SDH) over the posterior cerebri and the cerebellum
- Profound anoxic brain injury and axonal injury
- Bilateral diffuse intraretinal and focal preretinal hemorrhage, macular folds, and subdural and subarachnoid optic nerve sheath hemorrhages
- Healing left first-rib fracture

Case 3

A 2.5-month-old male infant was brought to a local ED because of cardiorespiratory arrest. He was the youngest of 3 brothers. He was born at 36 weeks' gestation and had an unremarkable neonatal course. Past medical history was remarkable for a 3-day admission to the hospital for vomiting and dehydration 9 days before current admission. He had not received any immunizations. Family history and social history were unremarkable.

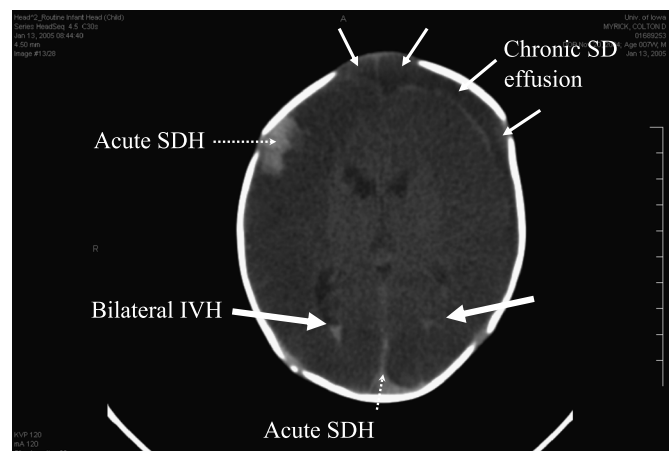


FIGURE 4. Acute SDH, bilateral intraventricular hemorrhage (IVH), and chronic subdural effusion at the time of last admission indicating multiple episodes of injury.

TABLE 1. Demographic and Clinical Features of Patients Related to Fatal AHT Episodes

Features	Patient 1	Patient 2	Patient 3
Age at last admission (mo)	6.0	3.5	3.0
Sex	Female	Male	Male
Perpetrator	Father	Father	Father
Initial history of accidental trauma	No	No	No
Evolving trauma history	No	Yes	Yes
Evidence of blunt head trauma	Yes	Yes	No
Mechanism of injury by confession	None	None	Shaking
Lucent period	Unknown	None	None
Time to intervention	Unknown, probably <12 h	15–20 min	15–20 min
Ocular findings	Diffuse bilateral RH, macular fold in the right eye, and bilateral optic nerve hemorrhages	Diffuse bilateral RH and bilateral macular folds	Diffuse multilayer RH in the left eye, disk hemorrhages and one retinal hemorrhage in the right eye, and bilateral optic nerve hemorrhages
Clinical course	Deepening coma, diabetes insipidus, and death due to brainstem herniation	Deepening coma and death due to brainstem herniation	Deepening coma, diabetes insipidus, and death due to brainstem herniation
Time from insult to death (h)	Unknown, <24	70	72

RH indicates retinal hemorrhages.

On the day of the most recent admission, the patient was in the care of his father when he was found to be unresponsive and not breathing. He was then taken to the local ED by his parents where he was intubated and transferred to the university hospital. The Hospital Child Protection Consultation Team met with both parents at the PICU. They reported that the child was in his usual state of health until 12 days before admission, when he started vomiting in a gradually worsening manner. In 3 days, he was admitted to the hospital with persistent vomiting. During that admission, pyloric stenosis and meningitis were ruled out. Hemoglobin level was 7.4 g/dL, and a persistent bulging fontanel was documented, but imaging studies of the head were not done. His condition was diagnosed with viral syndrome and discharged to his parents after he stopped vomiting. Irritability and intermittent vomiting persisted, and 3 days after dis-

charge, he was seen by the local primary care physician, who reported that the child was healthy.

Initially, the parents denied any trauma including falls, impact to the head, and shaking to revive when they found the child unresponsive. Later, the father confessed that he had shaken the baby twice: the first time was 15 days before; and the second time, the day before the admission to the university hospital.

On physical examination, weight was at 50% and head circumference was at 90%. The sutures between the skull bones were split by 0.5 cm, and he had a tense, bulging fontanel. He was intubated and in deep coma with no spontaneous movement or response to manipulation. His pupils were round, fixed, and dilated with no response to light. He had nonspecific bruises on his chest, back, and arm. The rest of the examination results were within normal limits.

TABLE 2. Imaging Study Findings of Cases Related to Fatal AHT Episodes

Features	Case 1	Case 2	Case 3
Skeletal findings	Metaphyseal fracture on the right distal tibia	Healed old posterior fractures of the left 8th, 9th, 10th, and 11th ribs; healed old posterolateral fracture of the right seventh and eighth ribs; healing old lateral fractures of the left fourth and fifth ribs; and Salter-Harris type 2 acute fracture of the proximal right tibia	None
Head CT scan findings	Diffuse brain edema and diffuse hypoxic ischemic injury with cerebellar reversal sign	Diffuse supratentorial brain edema, increased intracranial pressure, and left convexity and posterior interhemispheric SDH/SAH	Diffuse brain edema/ischemia, bilateral posterior intraventricular hemorrhage, right-sided acute and subacute frontal and temporal SDH, and acute right intraparenchymal hemorrhage

SAH indicates subarachnoid hemorrhage.

TABLE 3. Features of Cases Related to the Presentation of the Missed Episode of Abuse

Features	Case 1	Case 2	Case 3
Perpetrator	Unknown, possibly father	Unknown, possibly father	Father
Trauma history	Tipped car seat over when leg was stuck under furniture	Fall off a couch, 2-y-old brother accused	None
Symptoms	Irritability and swollen leg	Pain on manipulation and crepitation over the chest	Irritability, vomiting, and bulging fontanel
Injury mechanism indicated by findings	Twisting forces	Squeezing forces	Shaking with or without impact
Diagnostic tools used	X-ray, physical examination	X-ray, physical examination	Abdominal USG and lumbar puncture, physical examination
Who missed injury	ED physician on call	ED physician on call and radiologist	Admitting pediatrician
Clinical course	Continued irritability	Rib fractures healed	Persistent vomiting and irritability

USG indicates ultrasonography.

Ophthalmology examination revealed one disk hemorrhage in the right eye and diffuse preretinal, intraretinal, and subretinal hemorrhages from ora to ora with multiple disk hemorrhages in the left eye.

Coagulation studies showed a mild coagulation abnormality, a prothrombin time of 13 seconds, and a partial thromboplastin time of 35 seconds. The hemoglobin level was 6.3 g/dL, the results of urine organic acids analysis were within normal limits, and the result of the urine illicit drug screening was negative. The skeletal survey result was negative. An initial head CT scan showed bilateral hyperacute SDH and diffuse cerebral swelling due to anoxic brain injury. A second head CT (Fig. 4) showed a diffuse brain edema, a bilateral posterior intraventricular hemorrhage, an SDH (both subacute and acute) over the right frontal and temporal convexity mixed with hypointense fluid around it, and an acute right intraparenchymal bleed adjacent to the lateral ventricle. The patient died because of brainstem herniation.

In addition to the previously stated findings, the findings of an autopsy revealed acute and subacute conditions. The acute conditions include the following:

- Subdural hematoma of cervical, thoracic, and lumbar spine; cerebral and cerebellar acute subarachnoid hemorrhages; acute intra-arachnoid hemorrhage of the spinal cord; and profound anoxic brain injury
- Subdural and subarachnoid hemorrhages around both optic nerves, extensive intraretinal hemorrhages of the left eye, rare intraretinal hemorrhages of the right eye, and scattered peripapillary fat hemorrhage (left more than right)

The subacute/chronic conditions include the following:

- Organizing bilateral cranial and spinal subdural membranes, subacute cerebellar anoxic injury (Purkinje cell loss accompanied by Bergmann glia proliferation and vascular proliferation), and subacute scattered optic nerve bleeding

The summary of the case findings are listed in Tables 1–3.

DISCUSSION

The cases of 3 infants, 2 males and 1 female, who died because of severe AHT are reported in this paper. All 3 infants had documented episodes of missed diagnosis of milder forms of abusive trauma in their past medical history because physicians did not consider abuse in differential diagnosis and/or because they misread the imaging studies in the ED.

Biological fathers were the perpetrators of all 3 fatal AHT cases. In one case, the perpetrator of the second episode admitted to having perpetrated the previous abuse. In the other two, although the children were in the care of the perpetrators of AHT at the time of the previous abuse, legally, their culpability remained nonconfirmed. The fatal AHT followed the missed diagnosis episode by 1 day, 12 days, and 6 weeks. The involved medical staff who missed the previous abusive trauma in each of the 3 cases were an ED physician and a radiologist, an ED physician, and a pediatrician, respectively.

It is well known that there may be significant non-concordance between radiologists and emergency physicians in interpreting imaging studies. Alfaro et al⁷ reported that the interpretation of head CT scans by radiologists and emergency physicians was at variance in 38.7% of a series of 545 cases. In 24.1% of the total sample, this misinterpretation had a potentially significant clinical impact. Arendts et al⁸ reported in a similar study that even senior ED staff misinterpreted head CT scans in a sample of 1282 cases, with a potential or actual negative consequence in 6.1%. In a study of imaging studies and their interpretation by pediatric ED physicians, Simon et al⁹ reported a nonconcordance rate of 9.8%, a clinical significance rate of 6.8%, and a change-of-management rate of 3.1%, as in the 2 patients with missed fractures in this paper.

In our series, 13% of all AHT cases had a history of missed diagnosis of physical abuse. Jenny et al⁶ reported that of the 173 children they reviewed, 31% had a history of medical examination with nonspecific findings where AHT diagnosis was missed. Fatality rate in the missed physical abuse cases in our series was 60% (3/5). The corresponding figure reported by Jenny et al,⁶ on the other hand, was 9% in the missed AHT group. This difference may be due to the difference in the number of cases in the two studies. Another possibility may be that the CPS might have not forwarded all medical records of each case to the Child Protection Team for review. Jenny et al⁶ reported that the mean time before correct diagnosis among the missed AHT cases was 7 days (range, 0–189 days), and the mean number of physician visits

before the trauma was recognized was 2.8 (range, 2–9 visits). In our case study, the mean time to diagnosis was 18.3 days (range, 1–42 days). In this period, 2 of the patients had only 1 visit each, whereas the last case was admitted to the hospital for 3 days followed by a follow-up examination before the final diagnosis of a second AHT. Jenny et al⁶ reported that in 7 (13%) of the children with unrecognized AHT, misinterpretation of radiological studies contributed to the delay in diagnosis. In our group, on the other hand, radiological misreading contributed to the missed diagnosis in 1 (33%) of the 3 cases. In another case with radiological findings of abuse, the radiologist did read it as suspicious for abusive trauma, but by that time, the child had been admitted to the PICU because of AHT. Jenny et al⁶ reported that 80% of the deaths in the group with unrecognized AHT might have been prevented by earlier recognition of abuse, compared with 100% of our cases.

CONCLUSIONS

It is very important to consider abusive trauma in the differential diagnosis when assessing a child with symptoms suggesting trauma. Physicians should keep in mind that the history of trauma provided by the caretakers may not represent the truth at all times and that the symptoms of trauma, particularly among young infants, can be nonspecific

in nature and variable in severity upon presentation. Communication among physicians (clinicians and radiologists) is of paramount importance in accurately assessing a trauma case.

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