PEDIATRICS

May 2001
VOL. 107
NO. 5

Evaluation and Management of Children Younger Than Two Years Old With Apparently Minor Head Trauma: Proposed Guidelines

Sara A. Schutzman, MD*; Patrick Barnes, MD‡; Anne-Christine Duhaime, MD§; David Greenes, MD*; Charles Homer, MD‖; David Jaffe, MD¶; Roger J. Lewis, MD, PhD#; Thomas G. Luerssen, MD**; and Jeff Schunk, MD‡‡

ABSTRACT. *Objective.* **In children <2 years old, minor head trauma (HT) is a common injury that can result in skull fracture and intracranial injury (ICI). These injuries can be difficult to detect in this age group; therefore, many authors recommend a low threshold for radiographic imaging. Currently, no clear guidelines exist regarding the evaluation and management of head-injured infants. We sought to develop guidelines for management based on data and expert opinion that would enable clinicians to identify children with complications of HT and reduce unnecessary imaging procedures.**

Methods. Evidence: **References addressing pediatric HT were generated from a computerized database (Medline). The articles were reviewed and evidence tables were compiled.**

Expert Panel: **The multidisciplinary panel was comprised of nine experts in pediatric HT.**

Consensus Process: **A modified Delphi technique was used to develop the guidelines. Before the one meeting, panel members reviewed the evidence and formulated answers to specific clinical questions regarding HT in young children. At the meeting, guidelines were formulated based on data and expert consensus.**

Results. **A management strategy was developed that categorizes children into 4 subgroups, based on risk of ICI. Children in the high-risk group should undergo a computed tomography (CT) scan. Those in the intermediate risk group with symptoms of possible ICI should either undergo CT scan or observation. Those in the intermediate risk group with some risk for skull fracture or ICI should undergo CT and/or skull radiographs or observation. Those in the low-risk group require no radiographic imaging.**

Conclusions. **We have developed a guideline for the evaluation of children <2 years old with minor HT. The effect of these guidelines on clinical outcomes and resource utilization should be evaluated.** *Pediatrics* **2001; 107:983–993;** ***children, minor head trauma, evaluation, management, guidelines.***

ABBREVIATIONS. HT, head trauma; SR, skull radiograph; CT, computed tomography; ICI, intracranial injury; SF, skull fracture; LOC, loss of consciousness.

Head trauma (HT) is one of the most common childhood injuries, annually accounting for ~600 000 emergency department visits, 95 000 hospital admissions, and 550 000 hospital days; hospital care costs alone exceed 1 billion dollars per year.[1–4] Skull radiographs (SR) and computed tomography (CT) can accurately identify fractures and intracranial complications, respectively. However, their indiscriminate use wastes resources and raises costs. The American Academy of Pediatrics recently published guidelines for the management of minor closed head injury in children 2 to 20 years old; however, no recommendations were given for infants <2 years old.[5]

Children <2 years old have traditionally been considered separately, with the sense that they are at higher risk for injuries and more difficult to assess. In 1987, Masters et al[6] published proposed guidelines for imaging after HT based on a prospective Food

From the *Division of Emergency Medicine, Children's Hospital, Harvard Medical School, Boston, Massachusetts; ‡Pediatric Neuroradiology, Lucile Salter Packard Children's Hospital, Stanford University Medical School, Palo Alto, California; the §Division of Neurosurgery, Children's Hospital of Philadelphia, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania; the ‖Division of General Pediatrics, Children's Hospital, Harvard Medical School, Boston, Massachusetts; the ¶Division of Emergency Medicine, St Louis Children's Hospital, Washington University School of Medicine, St Louis, Missouri; the #Department of Emergency Medicine, Harbor–UCLA Medical Center, UCLA School of Medicine, Torrance, California; the **Division of Neurosurgery, Riley Hospital for Children, Indiana University School of Medicine, Indianapolis, Indiana; and the ‡‡Division of Emergency Medicine, Primary Children's Medical Center, University of Utah School of Medicine, Salt Lake City, Utah.

Received for publication Apr 28, 2000; accepted Sep 1, 2000.

Reprint requests to (S.A.S.) Division of Emergency Medicine, Children's Hospital, 300 Longwood Ave, Boston, MA 02115. E-mail: schutzman@a1.tch.harvard.edu

and Drug Administration-sponsored multicenter trial. Being <2 years old, even without symptomatology, was considered a moderate risk factor. Imaging or extended close observation for these patients was recommended unless the injury resulted from very trivial trauma. However, very trivial trauma was not defined. More recent studies have also recommended a low threshold for imaging infants <1 year old with HT.[7,8] Children <1 to 2 years old differ from older children and adults in several ways that may make a low threshold for imaging prudent. Clinical assessment is more difficult, asymptomatic (or occult) intracranial injury (ICI) occurs commonly, the risk for nonaccidental trauma is higher, the incidence of skull fractures (SFs) from minor trauma is greater, and leptomeningeal cysts (growing fractures) may develop.[9–15] Yet universal imaging is likely unnecessary. Additionally, children in this age group undergoing CT may require sedation, which carries risks including hypoxia, apnea, prolonged depressed level of consciousness, aspiration, and the need for tracheal intubation and mechanical ventilation.[16–18]

There are several limitations in the current recommendations of a low threshold for imaging children <2 years old with minor HT: 1) there is no uniformity in published recommendations regarding which children <2 years old with HT require imaging or which imaging modality is preferred when imaging is indicated; 2) only limited numbers of young children have been studied; and, 3) the recommendation for imaging all children <2 years old is not followed in practice and may be impractical.[19–21]

PURPOSE AND SCOPE

The purpose of this project was to use evidence and expert consensus to devise guidelines for the evaluation and management of children <2 years old with apparently minor HT that ensure the prompt identification of children with ICI and reduce unnecessary imaging procedures and hospital admissions.

Minor HT is defined as a history, or physical signs, of blunt trauma to the scalp, skull, or brain in an infant or child who is alert or awakens to voice or light touch. The guidelines are not intended to address children with birth trauma, penetrating injury, existing neurologic disorder, bleeding diathesis, previous intracranial surgery, multiple trauma, or those for whom significant concern for abuse or neglect exists during the initial evaluation (history and physical examination). ICI is defined as intracranial hematoma, cerebral contusion, and/or cerebral edema.

METHODS

Evidence

The data were culled from a list of references that had been generated by the American Academy of Pediatrics for the technical report of a practice parameter for minor HT in children.[5] These publications were identified using computerized databases (Medline through 1998) searching the English language literature for head injuries in children. Additional articles were identified from the bibliographies of the articles retrieved. A total of 404 articles were reviewed.

The criteria for evidence inclusion were that the publication: 1) include children <2 years old with minor HT; 2) contain relevant abstractable data separated out for those children; 3) be conducted in the era that included CT as part of clinical practice; and 4) not focus on birth injuries or abuse. When articles with data for children <2 years old did not exclusively address infants with minor HT, the neurologic status of the population was noted. Data were abstracted by the first author from each article onto a master data form. Also included were data from 3 studies in preparation for manuscript submission by panel members; these studies have since been published.[9,19,21]

Data were compiled into evidence tables to address the following specific clinical questions regarding evaluation and management of infants and young children with minor HT: 1) What are the indications for CT? 2) What are indications for SRs? 3) If a fracture is noted on SR, should CT be obtained? 4) If a CT is normal, which children can be safely discharged from the hospital? 5) If an isolated fracture is diagnosed but no ICI is present on CT, what are the criteria for discharge? 6) What are discharge criteria for children who do not receive imaging and for those with normal SRs? 7) Given that CT may miss some SFs that are identified by SR, is it acceptable not to identify a SF in a child with a normal CT in whom abuse or neglect is not a concern (ie, if the CT is negative, are SR necessary)? 8) Is it acceptable not to identify a fracture in an asymptomatic patient in whom abuse or neglect is not a concern? 9) What constitutes trivial HT? 10) Is there a role for observation as an alternative to imaging? If so, for which children?

Composition of Expert Panel

The first author selected the expert panel, which was composed of 9 full-time academic faculty with nationally recognized expertise in pediatric HT. The panel included 4 pediatric emergency medicine physicians, 1 emergency medicine physician with expertise in pediatric HT and statistical analysis, 2 pediatric neurosurgeons, 1 pediatric neuroradiologist, and 1 general pediatrician with expertise in HT and clinical epidemiology.

Consensus Process

A modified Delphi technique was used to develop the guidelines.[22] There was 1 closed meeting of the panel with the goal of reaching a consensus regarding answers to the specific clinical questions identified. Before the meeting, each panel member was provided with the draft management algorithm, clinical questions, evidence tables, bibliography, and selected references. Panel members were asked to review the material and to formulate an answer to each question before the panel meeting. At the time of the meeting, members of the panel presented their initial answers and then the panel attempted to reach a consensus regarding appropriate management strategies. Consensus was based on the available data, when sufficient, or on expert opinion in the absence of sufficient data. Alternative management strategies were accepted when a consensus could not be reached.

The management strategy was based on the likelihood of a patient's having an ICI. The detection of SF, which is associated with ICI, was also considered. Patient history and physical examination findings were used to categorize the child's risk of ICI. The patient's risk status was then used to recommend appropriate imaging and clinical management.

A statistician who was consulted for review of the data and evidence tables was present at the meeting for any questions but was not a panel member. Based on results of the meeting, practice guidelines were drafted by the first author and distributed to all panel members for their review. The guidelines were revised and again circulated to the panel for comments, which were incorporated into the final guidelines.

RESULTS

Evidence

Space constraints preclude a comprehensive report of the results of the literature review. A summary is provided of data relevant to questions regarding imaging and disposition.

1. What are indications for CT?

CT is considered the standard for diagnosis of acute ICI, although sensitivity may be reduced for

the posterior fossa. Identifying ICI is important to minimize secondary brain injury, prevent complications (eg, anticonvulsants to help prevent seizures in children with cerebral contusions), counsel parents, and document abuse. Summarized below are the data regarding the incidence of ICI and predictors for ICI.

The incidence of ICI among young children with minor HT is ~3%–6% (Table 1). The few studies that subdivide by age show a higher incidence in younger infants.[8,19,21]

Clinical predictors of ICI include SF, altered mental status, focal neurologic findings, scalp swelling, younger age, inflicted injury, and head injury with no clear history of trauma (Table 2). Loss of consciousness (LOC) and vomiting have not been shown to be predictors of ICI. Of note is that many young children with ICI had no signs or symptoms of brain injury. Asymptomatic, or occult, ICI is significantly more prevalent in younger aged children, particularly those <3 to 6 months old.[9,21]

The incidence of SF among children with ICI ranged from 60%–100% (Table 3). Although not completely sensitive, SF was found to be a better predictor for ICI in children with minor HT than clinical symptoms.[8,21,23]

2. What are indications for SRs?

SRs can diagnose SF. SF is one of the strongest predictors for ICI, and may lead to complications such as an enlarging cephalohematoma, or, quite rarely, a growing fracture.[24–26] Summarized below are incidence data and predictors for SF.

The incidence of SF in outpatients presenting for the evaluation of HT ranges from 6%–30% (Table 4). A higher incidence is reported in the younger age group.

Younger age and scalp hematoma (particularly temporal and parietal) are predictors for SF (Table 5). The presence of scalp hematoma is 80%–100% sensitive for associated SF.

3. If a fracture is noted on SR, should CT be obtained?

In most studies of children with SF, an associated ICI was present in 15%–30% (Table 6). SF is a predictor for ICI (Table 2).

4. If the CT is read as normal, which children may be discharged from the hospital?

Table 7 shows that in 3 studies (total 261 patients) the incidence for late deterioration in children with a normal CT was zero (95% confidence interval = 0, 1.4%).

5. If a linear SF is diagnosed but no ICI is present, what are criteria for discharge?

Table 8 shows that in 6 studies (total 349 patients) the incidence of clinical deterioration for children with isolated SF was zero (95% confidence interval = 0,1.0%).

MANAGEMENT STRATEGY: IMAGING RECOMMENDATIONS

The management strategy, outlined in Fig 1, subdivides children with minor blunt HT into 4 groups:

TABLE 1. Incidence of ICI in Outpatients Less Than Two Years Old Presenting for Evaluation

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	Neurologic Status of Population	Incidence of ICI
Schunk[23]	1996	Retrospective cohort	<18 y, GCS = 15, nonfocal neuro, CT for HT	96	GCS = 15, nonfocal neuro	6.1% (6/96; 5/6 <1 y)
Quayle[8]	1997	Prospective cohort	<18 y, nontrivial HT, CT/SR	134	Nontrivial HT; 89% alert	5.2% (7/134) overall; by age: ≤3 mo: 16% (5/32); 4 to 6 mo: 0% (0/22) 7 to 12 mo: 4% (2/49); 13 to 24 mo: 0% (0/26)
Greenes[21]	1999	Prospective cohort	Age <2 in ED for HT	608	92% alert/active. 5% alert but quiet	4.9% (30/608) overall; by age: <3 mo: 13% (12/92); 3 to 5 mo: 7% (4/56) 6 to 11 mo: 5% (9/168); 11 to 23 mo: 1.8% (5/271)
Ramundo[20]	1995	Prospective cohort	<19 with CT for HT; any GCS	37	76% GCS = 15 85% GCS ≥13	22% (8/37; also includes basilar and depressed SF)
Gruskin[19]	1999	Retrospective cohort	Age <2 in ED for HT	278	95% alert (264/278)	3.4% for alert patients (9/264); overall, 4.3% (12/278)
Dietrich[14]	1993	Prospective cohort	Age <21 with HT who had CT	71	80% GCS = 15 (57/71)	3.5% for GCS = 15 (2/57); overall, 4.2% (3/71)
Stewart[32]	1993	Retrospective cohort	<3 mo in ED for any trauma	111 51 with HT	?	5.9% (3/51)

GCS indicates Glasgow Coma Score; neuro, neurologic examination; ED, emergency department.

TABLE 2. Predictors for ICI

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	Risk Factors for ICI
Schunk[23]	1996	Retrospective cohort	Age <18 with CT for HT, GCS = 15, nonfocal neuro	96 6 ICI	Skull fracture NOT predictive: LOC, vomiting, seizure, sleepiness
Quayle[8]	1997	Prospective cohort	Age <18, nontrivial HT, CT, and SR	134 7 ICI	SF, focal neuro, young age (particularly <3 mo) symptoms: 6/7 alert/nonfocal; 5/6 no symptoms, only scalp findings and SF
Greenes[21]	1999	Prospective cohort	Children <2 evaluated in ED for HT	608 30 ICI	Parietal swelling, h/o lethargy or altered MS on exam, unclear mechanism of injury, SF, young age (<6 mo); ANY sign or symptom: sensitivity = 0.52 specificity = 0.72 NOT predictive: vomiting, LOC (80% of patients with ICI were alert and active or alert but quiet; 16% fell <3 ft)
Ramundo[20]	1995	Retrospective cohort	<19 with HT and CT; (76% GCS = 15)	37	Abuse, depressed SF, focal motor abnormality, anisocoria NOT predictive: LOC, vomiting, seizure, MVC
Gruskin[19]	1999	Retrospective cohort	<2 evaluated in ED for HT	278 12 ICI	Age <12 mo, fall >3 ft, focal neuro, GCS <15, scalp abnormality NOT predictive: LOC, vomiting, seizure, behavior change. Of note: 75% were alert with nonfocal neuro
Duhaime[28]	1992	Prospective cohort	Children <2 admitted with HT	100 25 ICI	MVC ($P < .0002$) inflicted injury ($P < .0002$)
Shane[24]	1993	Case series	Age ≤1 alert, admitted with SF	102 ≤1 15 ICI	Temporal SF, lethargy (either before or in ED; only 47% sensitive) presence of ANY sign or symptom was 100% sensitive and 35% specific (include LOC, seizure, vomiting, altered MS or behavior, focal neuro)
Bonadio[33]	1989	Case series	Pediatric patients with parietal SF who had CT	52 <1 20 ICI	17/20 had 1 or more of following: LOC/altered MS, abnormal neuro, complicated SF; of the other 3, 2 were <6 wk without symptoms
Dietrich[14]	1993	Prospective cohort	<21 with CT for HT	71; 3 with ICI (2 GCS = 15)	Of 3: 1 with LOC, 1 focal neuro, 1 GCS ≤14
Schuynoll[34]	1993	Prospective cohort	CT for HT	*N* <2 y not noted	4 patients <2 had fallen and had signs suspicious for SF but were otherwise acting appropriately

GCS indicates Glasgow Coma Score; neuro, neurologic examination; ED, emergency department; MVC, motor vehicle collision; MS, mental status.

1) those at high risk for ICI, in whom CT is indicated; 2) those at some risk for ICI with potential indicators of brain injury in whom CT and/or observation is indicated; 3) those without symptoms of brain injury who are at some risk for SF or ICI in whom CT and/or SRs or observation is indicated; and 4) those at low risk for ICI, for whom imaging is not necessary. Because these guidelines are intended for use by physicians in a variety of clinical settings, several options are offered in certain areas. The most appropriate strategy should be based on the clinical findings of the individual patient and the resources available.

It is assumed that the physician is qualified and performs a thorough and age-appropriate clinical evaluation. It is not the purpose of this document to detail the standards regarding the performance of a history and physical examination in an infant or young child with HT. However, the authors point out that if evaluated very shortly after the traumatic event, some children with fractures may not have scalp swelling. Also, scalp swelling may be less obvious in hirsute or dark-skinned infants.

Some general principles for using these guidelines are as follows:

1. The younger the child, the lower the threshold should be for obtaining imaging studies. Younger patients have a higher incidence of complications and a higher incidence of asymptomatic ICI; additionally, the youngest patient is difficult to assess clinically.[8,9,19,21] Although clearly a continuum, children <12 months old are at higher risk than those who are older, and infants <3 months old are at the highest risk. The youngest infants (<3 months old) also require sedation less often for CT than do older infants and young children.[21]
2. The greater the severity and number of historical symptoms and physical signs, the stronger the consideration should be for obtaining an imaging study.
3. Discrete cut-offs cannot be provided for signs and symptoms along the continuum. However, the greater the forces involved (such as those experienced in motor vehicle collisions, falls from greater heights or onto harder surfaces), the more pronounced the physical findings such as scalp swelling, and the younger the age, the greater the risk of ICI.[8,9,19,21]
4. Although not directly addressed by this article, all children with HT should be evaluated for ex-

TABLE 3. Incidence of SF Among Patients Less Than Two Years Old With ICI

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	% of ICI Who Have SF
Greenes[21]	1999	Prospective cohort	<2 in ED for HT	608	77% (23/30)
Schunk[23]	1996	Retrospective cohort	<18, GCS = 15, nonfocal, CT for HT	96	100% (6/6)
Quayle[8]	1997	Prospective cohort	<18, nontrivial HT, CT, and SR	134	100% (7/7)
Greenes[9]	1998	Case series	<2 with ICI	101	72% overall (73/101) 95% of occult (18/19); 67% of symptomatic (55/82)
Dietrich[14]	1993	Prospective cohort	Age <21 with CT for HT	71	67% (2/3)
Gruskin[19]	1999	Retrospective cohort	<2 in ED for HT	278	75% (9/12)
Duhaime[28]	1992	Prospective cohort	<2, admitted with HT	100	3/3 with EDH had SF 10/22 with SDH had SF (45%)
Schutzman[35]	1993	Case series	Children with EDH	13	82% (9/11; 2 unknown)
Mohanty[36]	1995	Case series	Children with EDH	5	40% (2/5)
Shugarman[37]	1996	Case series	<3, admitted with EDH or SDH	93	51% of SDH 68% of EDH
Schuynoll[34]	1993	Prospective cohort	CT for HT; ? GCS	*N* <2 y not noted	All patients <2 with ICI had SF
Leggate[38] (some pre-CT)	1989	Case series	<2 with EDH	40	83% (33/40)
Gutierrez[39] (some pre-CT)	1981	Case series	EDH <16 y	10	70% (7/10)

ED indicates emergency department; EDH, epidural hematoma; SDH, subdural hematoma; GCS, Glasgow Coma Score.

tracranial injuries. Likewise, the possibility of intentional injury or neglect must be considered when a young child is evaluated for HT.

Clinical Groups

High-Risk Group

The high-risk group consists of patients with signs or symptoms concerning enough for ICI that a CT scan is indicated. Data support that patients should be considered high risk if they have 1) depressed mental status[19,21,24] (difficulty bringing the child to an awake state and/or the child does not maintain an awake state; not normally arousable); 2) focal neurologic findings[8,19]; 3) signs of depressed or basilar SF[27]; 4) acute SF by clinical examination or by SR, if already done[8,20,21,23,24]; 5) irritability (not easily con-

TABLE 4. Incidence of SF in Outpatients Less Than Two Years Old Presenting for Evaluation

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	Incidence of SF
Greenes[21]	1999	Prospective cohort	<2 with HT in ED	608	14% overall (86/608) (23% <1; 4% 1–2 y)
Boulis[10]	1978	Retrospective cohort	Age <12, outpatients with SR for HT	68 <1 y	8.8% (6/68)
Ros[40]	1992	Retrospective cohort	Age <1, in ED, no symptoms, SR for HT	35	8.5% (3/35)
Leonidas[11]	1982	Retrospective cohort	<18, outpatient SR for HT, not severe	35 <1 y	14% (5/35)
Quayle[8]	1997	Prospective cohort	<18, nontrivial HT, CT and SR	134	20.8% (28/134) overall; by age: ≤3 mo 39%, 4 to 6 mo 18%, 7 to 12 mo 15%, 13 to 18 mo 11%, 19 to 24 mo 0%
Schunk[23]	1996	Retrospective cohort	<18, CT for HT, GCS = 15, normal neuro	96	46% (44/96) overall; by age: <1: 51% (31/61); 1–2: 37% (13/35)
Dietrich[14]	1993	Prospective cohort	Age <21 with HT who had CT	71	17.5% for GCS = 15 (10/57) 15% total group (11/71)
Gruskin[19]	1999	Retrospective cohort	Age <2 in ED for HT	278	17% overall (48/278); 8% of unreferred patients Total by age: <1 y: 29%, 1 to 2: 4% ($P < .001$) Unreferred by age: <1: 14%, 1 to 2: 1% ($P < .001$)
Stewart[32]	1993	Retrospective cohort	<3 mo in ED for any trauma	111 total 51 HT	27% (14/51); 44% of abused group, 20% of nonabuse
Joffe[41]	1988	Retrospective cohort	<19, in ED for stair falls	127 (88 with HT)	Of those with HT, by age: <1: 10% (4/39); 1 to 2: 2% (1/49)
Partington[31]	1991	Retrospective cohort	Age <2 with HT	129	30% (39/129)
Rivara[15]	1984	Prospective cohort	Age <18 in ED for HT NOT due to MVC	546 000 patients <18	6% <1 (accounted for 37% of all SF <18) 0.4% age 1 to 2

ED indicates emergency department; MVC, motor vehicle collision.

TABLE 5. Predictors for SF

A. Risk Factors for SF in General HT Population

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	Risk Factors
Boulis[10]	1978	Retrospective cohort	<12, outpatients with SR for HT	68 <1 6 SF	Age <1
Leonidas[11]	1982	Retrospective cohort	Age <18 with SR for HT (no severe HT)	35 <1 5 SF	Age <1
Lloyd[7]	1997	Prospective cohort	846 admitted patients with HT and 38 outpatients with SF	193	Age <2 (compared with older patients; did not compare patients <1 with those 1–2)
Quayle[8]	1997	Prospective cohort	<18, nontrivial HT, SR and CT	134 28 SF	Age <6 mo, scalp hematomas (83% (20/24) with SF had hematoma)
Greenes[29]	2001	Prospective cohort	<2, in ED for HT; asymptomatic CT or SR imaging	172 45 SF	Scalp swelling, especially moderate–large; parietal/temporal location; age <12 mo (40/45 with SF had swelling; 4/5 without swelling were <3 mo)
Gruskin[19]	1999	Retrospective cohort	<2, in ED for HT	278 48 SF	<12 mo, scalp abnormality (95% of SF had scalp abnormality)

B. Findings Associated With SF in Studies Exclusively of Children With Fractures

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	Risk Factors
Greenes[30]	1997	Case series	<2 admitted with SF	101	90% <12 mo; 96% with scalp abnormality 30% of free falls were <3 ft
Shane[24]	1993	Case series	≤1 admitted with SF	102 ≤1	96% with hematoma
Kleinman[42]	1992	Case series	Accidental HT, CT showing SF	14	100% with overlying scalp swelling (4–15 mm by CT)

ED indicates emergency department.

TABLE 6. Incidence of ICI Among Patients Less Than Two Years Old With SF

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	% of SF Who Have ICI
Greenes[21]	1999	Prospective cohort	<2, in ED for HT	608	27% (23/86)
Schunk[23]	1996	Retrospective cohort	<18, CT for HT, alert, normal neuro	96	14% (6/44)
Shane[24]	1993	Case series	≤1, awake, admitted with SF	102 ≤1	15% (15/102; only 32 had CT, so asymptomatic ICI may have been missed)
Bonadio[33]	1989	Case series	Pediatric patients, parietal SF with CT	52 ≤1	38% (20/52)
Dietrich[14]	1993	Prospective cohort	Age <21 with CT for HT	71	18% (2/11)
Gruskin[19]	1999	Retrospective cohort	<2, in ED for HT	278	19% (9/48)
Duhaime[28]	1992	Prospective cohort	<2, admitted with HT	100	18% (13/55)
Stewart[32]	1993	Retrospective cohort	<3 mo, in ED for trauma	51 HT <3 mo	21% (3/14) overall 42% of abuse, 0% of nonabuse
Ros[40]	1992	Retrospective cohort	<1 y, asymptomatic with SR for HT	35	0/3
Mann[13] (some pre-CT)	1986	Case series	Admitted pediatric patients with HT	2122	1.9% (10/515; unclear how many had CT)

Neuro indicates neurologic examination; ED, emergency department.

TABLE 7. Incidence of Deterioration in Children With Normal CT

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	Incidence of Deterioration
Greenes[21]	1999	Prospective cohort	<2, in ED for HT	608	0/104
Quayle[8]	1997	Prospective cohort	Nontrivial HT; CT and SR	134 total	0/105 with normal CT deteriorated
Schunk[23]	1996	Retrospective cohort	<18, CT for HT, alert, normal neuro	96	0/52 with normal CT had a repeat CT, surgery, or returned to ED

ED indicates emergency department; neuro, neurologic examination.

soled)[21]; or 6) bulging fontanel.[21] Although available data do not demonstrate that either seizure,[19,21,23] vomiting[8,19–21,23] or LOC[19–21,23] are independent predictors for ICI, expert consensus was that a child with a seizure, progressively worsening vomiting, or LOC as judged by caretakers as longer than 1 minute should undergo CT. Because vomiting has not been shown to be an independent risk factor, any cutoff regarding the number of episodes or duration necessary to prompt obtaining CT is inherently arbi-

TABLE 8. Incidence of Deterioration in Children With Isolated SF Not Initially Requiring Intervention

First Author	Year	Design	Eligibility Criteria	*N* <2 Years	Incidence of Deterioration
Greenes[30]	1997	Case series	<2 admitted with isolated SF	101 isolated SF	0 had late deterioration (2 needed intervention, apparent at diagnosis)
Quayle[8]	1997	Prospective cohort	Nontrivial HT, CT and SR	134 21 isolated SF	0/21 had deterioration
Shane[24]	1993	Case series	≤1, alert, admitted with SF	102 87 without ICI	0/87 without known ICI had deterioration
Partington[31]	1991	Retrospective cohort	<2 with HT	129 39 SF	0/39 had deterioration
Schunk[23]	1996	Retrospective cohort	CT for HT; alert, normal neuro	96 38 isolated SF	0/38 had deterioration
Greenes[21]	1999	Prospective cohort	<2, in ED for HT	608 63 isolated SF	0/63 had deterioration

Neuro indicates neurologic examination; ED, emergency department.

trary. However, panel consensus was that any child with vomiting 5 or more times or persisting longer than 6 hours should undergo CT. Furthermore, the expert consensus was that a low threshold should be adopted for CT of young infants (particularly those <3 months old) because of their relatively high incidence of ICI (including occult ICI), and the difficulties inherent in their assessment.

Intermediate Risk Group

This group consists of infants and children at some risk for a complication of head injury, in whom imaging or observation is indicated. This group is comprised of two subgroups of patients. Consensus is that for the first group either CT or observation are valid clinical options and for the second group an imaging procedure (CT and/or SR) or observation are valid clinical options.

1. Children with clinical indicators of possible brain injury:

This subgroup includes children with 1) 3 to 4 episodes of vomiting; 2) transient LOC (<1 minute); 3) history of lethargy or irritability (resolved by time of evaluation); 4) behavior not at baseline as reported by caretakers; and, 5) nonacute SF (>24 hours old). Although available data do not indicate that vomiting and transient LOC are independent predictors for ICI,[19–21,23] the panel consensus was that these findings should prompt the clinician to consider CT, particularly if the period of LOC was more than a few seconds and if vomiting occurred more than twice. Occasionally, children are brought for evaluation >24 hours after the traumatic event when a large scalp swelling is noted, and are diagnosed with a SF. If asymptomatic, these patients have passed the test of time for acute complications, so the risk of a clinically important ICI is likely lower than for patients with acute SFs. However, data are not available for the incidence of ICI in asymptomatic and well-appearing children with nonacute SF. When there is delay in evaluation, the clinician must also address any social concerns. Stronger consideration for obtaining a CT is necessary a) if >1 of the above factors is present; b) if the LOC was longer than 15 to 30 seconds; c) if the behavior change was significant or prolonged (eg, was poorly responsive for 30 minutes); and d) for younger children.

If CT is not performed, consensus is that the child should be observed for 4 to 6 hours postinjury for the development of symptoms (eg, vomiting, change in level of alertness, behavior or neurologic examination). If symptoms develop, CT is indicated. If the patient remains without significant symptoms and fulfills all discharge criteria the child may be discharged.

CT may not detect a SF that courses parallel to the planes of CT section. If the CT is normal and there is no concern about abuse or neglect, SR is not necessary. Complex or depressed fractures are usually detected by CT or by clinical examination. The concern that CT may not diagnose every linear SF (which has a low risk of complications) does not warrant obtaining SR on every child with a normal CT.

2. Children with a concerning or unknown mechanism, or who have findings on physical examination that may indicate an underlying SF:

This subgroup includes children with 1) a higher force mechanism (eg, high speed motor vehicle collision or child ejection, falls >3–4 feet)[19,21,28]; 2) falls onto hard surfaces (eg, concrete, linoleum or wood), especially in a younger child; 3) scalp hematomas, particularly if large, boggy, or located in the temporoparietal area[21,29] (frontal hematomas are at low risk for complications,[29] particularly in ambulatory patients with low energy mechanisms); 4) unwitnessed trauma with the possibility of a significant mechanism (eg, thump heard and child found crying at the bottom of the stairs); and, 5) a vague or absent history of trauma in the setting of signs or symptoms of HT (eg, a scalp hematoma with no clear history of trauma; this scenario should also raise the suspicion of possible child abuse or neglect, particularly in a nonambulatory child). Depending on the clinical situation, CT or SR should be considered. When deciding between these imaging modalities, issues to consider include the clinical scenario, availability of SF and CT, accuracy of imaging interpretation, expertise of available radiologist and need for sedation. Children with acute SF noted on SRs should undergo CT

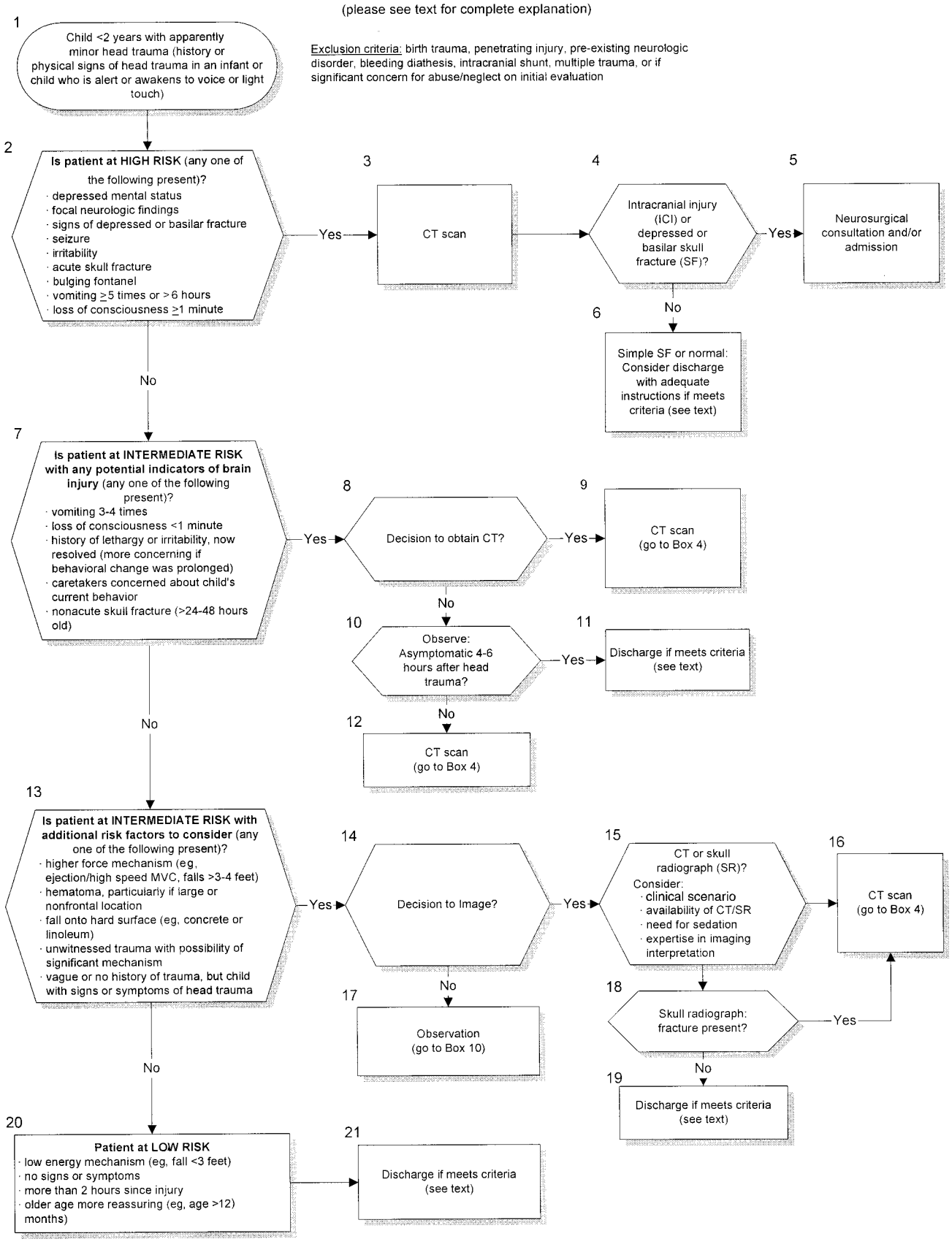

Fig 1. Management strategy: imaging recommendations.

because SF significantly increases the likelihood of an ICI.

If radiographic imaging is not performed, consensus is that the child should be observed for 4 to 6 hours postinjury for the development of symptoms (eg, vomiting or change in level of alertness, behav-

ior or neurologic examination). If symptoms develop, CT is indicated. If the patient remains without significant symptoms and fulfills all discharge criteria the child may be discharged.

Low-Risk Group

The low-risk group consists of patients with HT whose injuries are trivial and who have a very low likelihood of an ICI. This category includes children with low-energy mechanisms (eg, fall <3 feet) who have no signs or symptoms at least 2 hours after the injury. Within this group, an age >3 to 6 months is more reassuring. Even with trivial mechanisms, the risk of having or developing an ICI is not zero, so an observation period for onset of signs and symptoms of ICI is still warranted. If the child has reliable caretakers, this observation may occur at home, after appropriate discharge instructions are given.

MANAGEMENT BASED ON IMAGING RESULTS

Expert consensus is that a neurosurgeon should be consulted for any child with an ICI noted on CT and for any child with a depressed, basilar, or widely diastatic SF. Specific management will be based on the individual case. Children with ICI noted on CT and those with depressed or basilar SF will usually require admission.

Children with isolated simple SF (ie, a single fracture that has margins separated by <3 mm, is not depressed, is restricted to a single bone, and has no associated ICI noted on CT) may be considered for discharge if they meet discharge criteria (see below). One theoretical concern regarding a child with a SF is delayed intracranial hemorrhage and subsequent deterioration. The limited data existing on this topic suggest that the incidence is extremely low.[8,21,23,24,30,31] However, admission may be considered for children who are potentially at higher risk. Although insufficient data exist to define risk factors, the panel consensus was that patients with the following be considered higher risk for delayed complications: a) younger age (particularly those <3 to 6 months old who are more difficult to assess and may lose significant blood into large scalp hematomas); b) large scalp swellings and fractures resulting from a high-energy mechanism (eg, fall onto head from the second story); or c) concerning fracture location (eg, crossing a suture, dural venous sinus, vascular groove, or extending into the posterior fossa).

Children with no evidence of ICI on CT are at low risk for clinical deterioration and late complications. They may be considered for discharge if they meet the criteria. No sufficient data exist to comment on whether a child with a negative CT obtained within a short time after the trauma requires a period of observation before discharge. Children who do not require CT and those who have normal SR may be discharged if they meet discharge criteria.

DISCHARGE CRITERIA

Discharge may be considered (after appropriate evaluation, with imaging, observation, or neurosurgical consultation as indicated) if:

1. The child has no significant extracranial injuries or other indications (eg, unremitting vomiting) for admission;
2. The child easily alerts and has a normal neurologic examination;
3. There is no suspicion of abuse or neglect; and
4. The child lives in relatively close proximity to health care and has reliable caretakers who are able to return if necessary.

DISCHARGE INSTRUCTIONS

The risk of delayed deterioration is low but not zero in any child who is discharged. Consensus is that it is mandatory that discharge instructions be provided to competent caretakers regarding signs and symptoms of complications of HT. This guideline does not address the content of those instructions.

DISCUSSION

We have presented specific guidelines for the evaluation and management of minor HT in children <2 years old. Definitive recommendations for all cases cannot be made for several reasons. The available data are limited and no predictor or combination of predictors is 100% sensitive for identifying ICI. Many variables such as age and height of fall are continuous; therefore, recommendations based on discrete cut-offs would be arbitrary and misleading. The risk for ICI may be based on many factors (eg, age, height of fall, size of scalp swelling, change in behavior), and it is not possible to address every conceivable clinical situation. Nevertheless, we have endeavored to provide as specific a set of recommendations as possible.

These guidelines include the optional use of SR, which is a controversial topic. Inherently, SR is of limited value because little or no information about ICI is provided. However, SR may still have some role in the evaluation of HT in the infant and young child because these patients are at higher risk for SF, have a higher incidence of occult ICI, and SF is one of the best predictors for ICI.[7–11,14,15,21,23] Sedation is the main obstacle to obtaining CT in this age. Although most children receiving sedation do well when properly monitored, a small number experience complications, most commonly transient respiratory depression and oxygen desaturation; rarely, more significant complications occur.[17,43–45] Additionally, postsedation side effects including sleepiness, unsteadiness and vomiting may occur, which can complicate observation of the head-injured child for signs of increased intracranial pressure.[17] Although only an indirect marker for ICI, the advantage of SR is that children do not require sedation for the study, and, less importantly, SR is less expensive than CT. In any case where an ICI is suspected, CT should never be supplanted by SR. However, SR may be of some utility in an infant or child who has no symptoms of brain injury but is at some risk for SF (eg, presence of scalp swelling). The utility of SR obviously depends on the interpretive skills of the reader. The SR diagnosis of SF in children requires a working knowledge of the appearance of normal sutures,

synchondroses, vascular markings, and other normal skull variants. The clinician should therefore take into account his (and the radiologist's) expertise in reading the images when considering their use. Furthermore, as more data become available and with additional advances in CT technology to reduce the need for sedation, the indications for SR may be further reduced or become obsolete.

Although this algorithm excludes infants with obvious abuse by initial history or physical examination, it is important to note that during the course of evaluation of infants not initially suspected to be victims of intentional injury, concern and evidence for abuse may arise. This is why these guidelines discuss abuse (despite it being an exclusion criterion) and why discharge criteria include no suspicion for abuse. Clearly, any concern for inflicted head injury must be pursued.

There are several limitations that should be noted. Because of limited available data, these guidelines should be considered preliminary and should be validated and tested. Although all studies in the evidence tables included children with minor HT, due to the paucity of studies addressing only infants with minor HT, some studies also included infants with moderate trauma. When data were available for those exclusively with minor HT, it was recorded. When the population was mixed, eligibility criteria and neurologic status of the population was noted (Table 1). Another potential limitation is the composition of the expert panel. This multidisciplinary group represents the physicians that evaluate, manage, and conduct research on young children with HT in academic centers. In addition to pediatric emergency physicians, pediatric neurosurgeons and 1 pediatric neuroradiologist, the panel includes only 1 general pediatrician, 1 general emergency physician, and no family practitioner. The panel likely underrepresents the physicians who evaluate the majority of young children with HT and may have introduced some bias. The goal of these guidelines is to detect ICI to prevent secondary brain injury and long-term sequelae. Because the significance of all ICI is not known (particularly those that require no intervention), long-term follow-up of patients with asymptomatic ICI would be clinically important and might alter these recommendations.

Because specific clinical scenarios and resources vary, these guidelines are not intended to be applied rigidly to every child with HT. Physicians may choose to individualize care based on unique clinical circumstances, or they may adopt a variation of these guidelines based on a different interpretation of the literature concerning the issues we have addressed.

Following these guidelines will not completely eliminate the risk of missing complications of HT. Only performing imaging for every child would approach this goal, which is not feasible (or cost-effective) and carries risks in itself, especially if sedation is required. Rather, we believe these guidelines provide a reasonable approach to a complex clinical problem that will identify the overwhelming majority of clinically significant injuries. Additionally, because the current management of young children with minor HT is variable, more uniformity in care will allow a critical evaluation of this management strategy in the future. The effect of these guidelines on clinical outcomes and resource use should be evaluated.

ACKNOWLEDGMENTS

This project was supported by a grant from the David and Lucile Packard Foundation.

We thank Michael Wigotsky for his excellent research assistance; David Shapiro, PhD, for his statistical input; and Gary Fleisher, MD, for his invaluable guidance and support with this project and thoughtful review of the manuscript.

REFERENCES

1. Kraus J, Fife D, Cox P, Ramstein K, Conroy C. Incidence, severity, and external causes of pediatric brain injury. *Am J Dis Child*. 1986;140:687–693
2. Kraus J, Fife D, Conroy C. Pediatric brain injuries: the nature, clinical course, and early outcomes in a defined United States' population. *Pediatrics*. 1987;79:501–507
3. Kraus J, Rock A, Hemyari P. Brain injuries among infants, children, adolescents, and young adults. *Am J Dis Child*. 1990;144:684–691
4. Division of Injury Control, Centers for Disease Control. Childhood injuries in the United States. *Am J Dis Child*. 1990;144:627–646
5. Committee on Quality Improvement, American Academy of Pediatrics and Commission on Clinical Policies and Research, American Academy of Family Physicians. The management of minor closed head injury in children. *Pediatrics*. 1999;104:1407–1415
6. Masters S, McClean P, Arcarese J, et al. Skull xray examinations after head trauma: recommendations by a multidisciplinary panel and validation study. *N Engl J Med*. 1987;316:84–91
7. Lloyd D, Carty H, Patterson M, Butcher C, Roe D. Predictive value of skull radiography for intracranial injury in children with blunt head injury. *Lancet*. 1997;349:821–824
8. Quayle K, Jaffe D, Kupperman N, et al. Diagnostic testing for acute head injury in children: when are head computed tomography and skull radiographs indicated? *Pediatrics*. 1997;99:1–8
9. Greenes D, Schutzman S. Occult intracranial injury in infants. *Ann Emerg Med*. 1998;32:680–686
10. Boulis Z, Dick R, Barnes N. Head injuries in children: aetiology, symptoms, physical findings, and x-ray wastage. *Br J Radiol*. 1978;51:851–854
11. Leonidas J, Windsor T, Binkiewicz A, Vaz R, Scott R, Pauker S. Mild head trauma in children: when is a roentgenogram necessary. *Pediatrics*. 1982;69:139–143
12. Berney J, Favier J, Froidevaux A. Paediatric head trauma: influence of age and sex: I. Epidemiology. *Child's Nervous System*. 1994;10:509–516
13. Mann K, Chan K, Yue C. Skull fractures in children: their assessment in relation to developmental skull changes in acute intracranial hematomas. *Child's Nervous System*. 1986;2:258–261
14. Dietrich A, Bowman M, Ginn-Pease M, Kosnik M, King D. Pediatric head injuries: can clinical factors reliably predict an abnormality on computed tomography? *Ann Emerg Med*. 1993;22:1535–1540
15. Rivara F. Childhood injuries. III: Epidemiology of non-motor vehicle head trauma. *Dev Med Child Neurol*. 1984;26:81–87
16. Bailey P, Pace M, Ashburn M, Moll J, East K, Stanley T. Frequent hypoxemia and apnea after sedation with midazolam and fentanyl. *Anesthesiology*. 1990;73:826–830
17. Vade A, Sukhani R, Dolenga M, Habisohn-Schuck C. Chloral hydrate sedation of children undergoing CT and MR imaging: safety as judged by American Academy of Pediatrics guidelines. *AJR Am J Roentgenol*. 1995;165:905–909
18. Woolard D, Terndrup T. Sedative-analgesic agent administration in children: analysis of use and complications in the emergency department. *J Emerg Med*. 1994;12:453–461
19. Gruskin K, Schutzman S. Head trauma in children younger than 2 years: are there predictors for complications? [published erratum appears in Arch Pediatr Adolesc Med. 1999 May;153(5):453]. *Arch Pediatr Adolesc Med*. 1999;153:15–20
20. Ramundo M, McKnight T, Kempf J, Satkowiak L. Clinical predictors of computed tomographic abnormalities following pediatric traumatic brain injury. *Pediatr Emerg Care*. 1995;11:27–30
21. Greenes D, Schutzman S. Clinical indicators of intracranial injury in head-injured infants. *Pediatrics*. 1999;104:861–867
22. Dalkey N. The Delphi Method: an experimental study of group opinion.

Research Memorandum RM-58888-PR. Santa Monica, CA: The Rand Corporation; 1969
23. Schunk J, Rodgerson J, Woodward G. The utility of head computed tomographic scanning in pediatric patients with normal neurologic examination in the emergency department. *Pediatr Emerg Care*. 1996;12: 160–165
24. Shane S, Fuchs S. Skull fracture in infants and predictors of associated intracranial injury. *Pediatr Emerg Care*. 1997;132:1–6
25. Rahman N, Jamjoom Z, Jamjoom A, Murshid, Waleed R. Growing skull fractures: classification and management. *Br J Neurosurgery*. 1994;8: 667–679
26. Muhonen M, Piper J, Menezes A. Pathogenesis and treatment of growing skull fractures. *Surg Neurol*. 1995;43:367–373
27. Kadish H, Schunk J. Pediatric basilar skull fracture: do children with normal neurological findings and no intracranial injury require hospitalization? *Ann Emerg Med*. 1995;26:37–41
28. Duhaime A, Alario A, Lewander W, et al. Head injury in very young children: mechanisms, injury types, and ophthalmologic findings in 100 hospitalized patients younger than 2 years of age. *Pediatrics*. 1992;90: 179–185
29. Greenes D, Schutzman S. Clinical significance of scalp abnormalities in asymptomatic head-injured infants. *Pediatr Emerg Care.* 2001;17:88–92
30. Greenes D, Schutzman S. Infants with isolated skull fracture: what are their clinical characteristics, and do they require hospitalization? *Ann Emerg Med*. 1997;30:253–259
31. Partington M, Swanson J, Meyer F. Head injury and the use of baby walkers. *Ann Emerg Med*. 1991;20:652–654
32. Stewart G, Meert K, Rosenberg N. Trauma in infants less than three months of age. *Pediatr Emerg Care*. 1993;9:199–201
33. Bonadio W, Smith D, Hillman S. Clinical indicators of intracranial lesion on computed tomographic scan in children with parietal skull fracture. *Am J Dis Child*. 1989;143:194–196
34. Schynol W, Overton D, Krome R, Wesolowski D, et al. A prospective study to identify high-yield criteria associated with acute intracranial computed tomographic findings in head-injured patients. *Am J Emerg Med*. 1993;11:321–326
35. Schutzman S, Barnes P, Mantello M, Scott R. Epidural hematomas in children. *Ann Emerg Med*. 1993;22:535–541
36. Mohanty S, Thompson W, Rakower S. Are CT scans for head injury patients always necessary? *J Trauma*. 1991;31:801–805
37. Shugerman R, Paez A, Feldman K, Grady M. Epidural hemorrhage: is it abuse? *Pediatrics*. 1996;97:664–668
38. Leggate J. Extradural haematoma in infants. *Br J Neurosurg*. 1989;3: 533–539
39. Gutierrez F, Raimondi A. Acute subdural hematoma in infancy and childhood. *Child's Brain*. 1975;1:269–290
40. Ros S, Cetta F. Are skull radiographs useful in the evaluation of asymptomatic infants following minor head injury? *Pediatr Emerg Care*. 1992; 8:328–330
41. Joffe M, Ludwig S. Stairway injuries in children. *Pediatrics*. 1988;82: 457–461
42. Kleinman P, Spevak M. Soft tissue swelling and acute skull fractures. *J Pediatr*. 1992;121:737–739
43. Pomeranz ES, Chudnofsky CR, Deegan TJ, Lozon MM, Mitchiner JC, Weber JE. Rectal methohexital sedation for computed tomography imaging of stable pediatric emergency department patients. *Pediatrics*. 2000;105:1110–1114
44. Alp H, Guler I, Orbak Z, Karakelleoglu C, Tan H, Eren S. Efficacy and safety of rectal thiopental: sedation for children undergoing computed tomography and magnetic resonance imaging. *Pediatr Int*. 1999;41: 538–541
45. Pereira JK, Burrows PE, Richards HM, Chuang SH, Babyn PS. Comparison of sedation regimens for pediatric outpatient CT. *Pediatr Radiol*. 1993;23:341–344

WHAT THE BICYCLE HATH WROUGHT (1900)

. . . The bicycle, with its recently invented brakes and pneumatic tires, was seen by doomsayers as just another nail in the coffin of civilization. Women were riding bicycles, contributing to the decline of morals and accelerating the collapse of social harmony. Newfangled sports, rambling, and cycling threatened rank, order, and culture. . .

Newly obtrusive and newly mobile criminals, robbers, bag-snatchers, muggers, gangsters, and hooligans . . . use bikes to rob and stab and make their getaway. Juvenile delinquency is rife. Indeed, a lot of activities are publicized and a lot of notions are bandied about that come to us with a familiar sound: aggression, perversion, homosexuality, incest, drugs, immigrants, nerves, neurasthenia, depravity, unemployment, loneliness, isolation, transgression, anomie, and urbanization. Urban predators run wild in the streets, children brandish knives and pistols, parents are indifferent to the moral and physical well-being of their offspring, and the uncouth masses gain access to the precincts of their betters.

Weber E. *Apocalypses.* Cambridge, MA: Harvard University Press; 1999

Submitted by Student

Evaluation and Management of Children Younger Than Two Years Old With Apparently Minor Head Trauma: Proposed Guidelines

Sara A. Schutzman, Patrick Barnes, Anne-Christine Duhaime, David Greenes, Charles Homer, David Jaffe, Roger J. Lewis, Thomas G. Luerssen and Jeff Schunk

Pediatrics 2001;107;983
DOI: 10.1542/peds.107.5.983

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Evaluation and Management of Children Younger Than Two Years Old With Apparently Minor Head Trauma: Proposed Guidelines

Sara A. Schutzman, Patrick Barnes, Anne-Christine Duhaime, David Greenes, Charles Homer, David Jaffe, Roger J. Lewis, Thomas G. Luerssen and Jeff Schunk

Pediatrics 2001;107;983
DOI: 10.1542/peds.107.5.983