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Technical Report: Minor Head Injury in Children

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ABSTRACT. Minor head trauma affecting children is a common reason for medical consultation and evaluation. In order to provide evidence on which to base a clinical practice guideline for the American Academy of Pediatrics, we undertook a systematic review of the literature on minor head trauma in children.

***Methods.* Medline and Health databases were searched for articles published between 1966 and 1993 on head trauma or head injury, limited to infants, children, and adolescents. Abstracts were reviewed for relevance to mild head trauma consistent with the index case defined by the AAP subcommittee. Relevant articles were identified, reviewed, and abstracted. Additional citations were identified by review of references and expert suggestions. Unpublished data were also identified through contact with authors highlighting child-specific information. Abstracted data were summarized in evidence tables. The process was repeated in 1998, updating the review for articles published between 1993 and 1997.**

***Results.* A total of 108 articles were abstracted from 1033 abstracts and articles identified through the various search strategies. Variation in definitions precluded any pooling of data from different studies. Prevalence of intracranial injury in children with mild head trauma varied from 0% to 7%. Children with no clinical risk characteristics are at lower risk than are children with such characteristics; the magnitude of increased risk was inconsistent across studies. Computed tomography scan is most sensitive and specific for detection of intracranial abnormalities; sensitivity and specificity of skull radiographs ranged from 21% to 100% and 53% to 97%, respectively. No high quality studies tested alternative strategies for management of such children. Outcome studies are inconclusive as to the impact of minor head trauma on long-term cognitive function.**

Conclusions.* The literature on mild head trauma does not provide a sufficient scientific basis for evidence-based recommendations about most of the key issues in clinical management. More consistent definitions and multisite assessments are needed to clarify this field. *Pediatrics* 1999;104(6). URL: http://www.pediatrics.org/cgi/content/full/104/6/e78; *head trauma, imaging, literature review.

ABBREVIATIONS. CT, computed tomography; MRI, magnetic resonance imaging; GCS, Glasgow coma scale.

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

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Minor head trauma affecting a child is a common reason for medical consultation and evaluation. No consensus exists concerning the appropriate diagnostic assessment of such children. Previous surveys of physicians indicated significant variation in practice, and examination of hospitalization rates shows substantial regional variation for this condition. The American Academy of Pediatrics, in coordination with the American Academy of Family Physicians, launched an initiative to develop a clinical practice guideline to reduce variation and improve the quality of care of children with minor head trauma.

This report provides the technical information on the literature concerning minor head trauma in children that was used by the American Academy of Pediatrics/American Academy of Family Physicians subcommittee in formulating this guideline.

METHODS

The literature review included the following salient aspects of minor head trauma in children:

- Prevalence of intracranial injury
- Sensitivity and specificity of different imaging modalities in detecting intracranial injury, including skull radiography, computed tomography (CT), and magnetic resonance imaging (MRI)
- Utility of early diagnosis of intracranial injury
- Effectiveness of alternative management strategies, and
- Impact of minor head injury on subsequent child health.

The data included for review met the following criteria:

1. publication in a peer-reviewed journal,
2. data related exclusively to children or was identifiable as being specifically related to children, and
3. assurance that cases described in the article were comparable with the case described in the practice guideline. Review articles and expert opinion were excluded.

A medical librarian undertook an initial search of several computerized databases, including Medline (1966–1993) and Health, searching terms of head trauma and head injury, restricted to infancy, children, and adolescents. Four hundred twenty-two articles were identified. Titles and abstracts were reviewed by 4 initial reviewers, including the subcommittee chairperson, American Academy of Pediatrics staff, and methodologic consultants, and articles were obtained when reviewers considered the title to be relevant. Through this process, 168 articles were identified.

Articles were sent to subcommittee members with an article review form, which asked reviewers to categorize the study design, identify the study question, and abstract the data to enable data pooling and meta-analysis. In addition, reviewers were asked to check the article references to see whether additional sources could be found.

Of the initial 168 articles sent out, reviewers excluded 134 papers and included 34 papers in their reviews.

An additional 125 references were identified through bibliog-

TABLE 1. Risk of Intracranial Injury: Mild Head Trauma

First Author	Cite	Year	Design	*n*	Eligibility Criteria	Outcome	Estimate
			GCS 15, CT Scan Outcomes				
Davis	9	1988–1992	Case series (post hoc, CART)	49	GCS 15, normal neurologic exam, isolated injury, history LOC/amnesia[i]	ICH	0% (0%–6%)
Dietrich	7	1993	Case series	195	GCS 15[ii]	Intracranial injury	5%
Hahn	8	1993	Case series	549	GCS 15	Mass lesions (epidural/subdural)	7.1%
				11	Trivial head injury[iii]	Abnormal CT scan (intracranial injury)	0%
Immordino	30	1986	Case series (retrospective)	143	LOC <5 min, posttraumatic amnesia <1 h	Subdural, epidural, or major neuro residual	0 (0/143)
Rosenthal	3	1989	Case series		All patients had LOC <1 h, 90% <5 min	Intracranial injury, ½ managed operatively	1.3% (.5%–2.8%)
Sekino	5	1981	Case series	171	None or brief LOC up to 10 min	Outcome = all abnormal CT scans ("small brain lesions")	7.6%
Zimmerman	31	1978	Case series	24	Alert, oriented, minimal or no LOC	Death	0 (0/24)
				54	(Includes adults for this)	Focal abnormality[iv]	22%
Schunk	32	1996	Case series	216 ≥2 y	GCS 15, normal exam who had CT done	Intracranial injury	3.2% (7/216)
			GCS 15, Clinical Outcomes				
Cline		1988	Case series	34	GCS 15, normal exam, age <15	Clinical deterioration	0%
Dacey	6	1986	Case series	230 children	Among GCS 15[v]	"Required" neurosurgical intervention	1.5%[vi]
			Unpublished Data				
Finkelstein		1994[vii]	Case series	134	Children 2–15, LOC 0–5 min, normal exam, GCS 15	"Significant" abnormal cranial CT scan	3.7% (5/134)
Stein		1994[viii]	Case series	582	Children with closed head injury, GCS 15 plus 1 of: (LOC, amnestic, dazed)	Intracranial lesion Neurosurgical procedure	9.6% 1.9%
Stein		1994[ix]	Case series	1992	Children with closed head injury, GCS 15, diagnosis of "intracranial injury" plus one of {LOC, amnestic, dazed}	Intracranial lesion Neurosurgical procedure	8.2% 5%
			GCS >12, Clinical and CT Outcomes, Published				
Hennes	1	1988	Case series	24	GCS >12	Abnormal CT (intracranial injury)	25%[x]
Dahl-Grove	40	1991–1992	Case series	62	GCS >12, mild head injury, normal CT scan (median, 15)	Abnormal neurological exam	0% (CI: 0%–6%)
Davis	4	1987–1992	Case series/ cohort	400[xi]	GCS >12, normal CT	a) Admission in subsequent month b) Neurosurgical intervention	a) 3/399 (1 with intracranial contusion) b) 0% (CI 0%–.75%)
Rivara	2	1987	Case series	51	GCS >12[xii]	Intracranial abnormal on CT	12%[xiii]

raphy tracing, of which 30 were included for review by the epidemiologist/pediatrician consultants.

All articles included were then abstracted again by the epidemiologist/pediatrician consultants, and the data were compiled using summary tables and evidence tables. Differences in case definition, outcome definition, and study samples precluded pooling of data to arrive at common estimates.

Because the published data proved extremely limited for a number of study questions, direct queries were given to several authors for child-specific data. Because these data have not been formally published, we did not rest strong conclusions on them; when available, however, they are presented with this report.

Because of the lengthy period between the initial review of the literature and final appproval of the guideline, a second literature review was performed to assure that the literature review was current. This literature review used the same search headings and targeted the period between January 1, 1993, and July 1, 1997. For this review, only an electronic search was performed. The review identified an additional 486 abstracts, of which 44 were selected

TABLE 1. Continued

First Author	Cite	Year	Design	n	Eligibility Criteria	Outcome	Estimate
			Pre-CT Era Studies				
Sainsbury	23	1984	Discharge data	35/28 701	Cases = symptomatic IC bleeding; denom = all admits Wales for head trauma	Intracranial bleeding	.12%
Teasdale	10	1990	(Community) heterodemic design	34	GCS 15 (oriented and alert) age 0–14	Intracranial hematoma undergoing surgery	.017% (1:5882)
Hendrick	33	?	Case series	1500	No LOC; includes neonates	Extradural, subdural, and "brain damage"[xiv]	about 9%

LOC, loss of consciousness; CI, confidence interval.

[i] Both multiple trauma (7/91) and "abnormal neurologic exam" (5/28) had much higher rates of ICH. No child required evacuation, although 1 multiple trauma and normal exam received intracranial monitoring. Neurologic abnormalities included subsequent disorientation focal weakness, agitation, lethargy/drowsiness.

[ii] All had either LOC, amnesia, headache, or vomiting; neurological examinations were normal.

[iii] Termed mild or moderate in article, defined as no history of or findings of altered MS, no headache or persistent vomiting, no seizures or focal deficit, and with or without facial or scalp hematomas, contusions, or laceration.

[iv] Contusion, hematoma, subdural, epidural.

[v] Of 90 adults and children in the study 15% had LOC; specific pediatric data on LOC not provided.

[vi] Three cases, all age 17–19.

[vii] Finkelstein, Homer, and Kleinman, personal communication, 2/10/94.

[viii] Personal communication, February 10, 1994, series from Cooper hospital.

[ix] Personal communication, February 10, 1994, series from NIDD.

[x] All had either headache or vomiting or impact seizure or LOC >5 minutes.

[xi] Three hundred ninety-nine excluding 1 patient who was receiving coumadin; that patient had a subsequent subdural hematoma requiring surgical evacuation.

[xii] All "symptomatic," ie, history of LOC, abnormal LOC in field or ED, or focal neurologic abnormality; cannot differentiate subtypes from data given.

[xiii] Increases to 20% if depressed skull fracture included; to 31% if linear skull fracture included.

[xiv] Brain damage = contusion, laceration, pulping of the brain, and intracerebral hemorrhage.

for detailed review by the epidemiologist and 11 included in the evidence tables.

RESULTS

In general, interpretation of clinical studies of head trauma was complicated by several characteristics of the literature. Specifically, the head trauma literature suffers by the nonstandardized ways of categorizing head injury, clinical examinations, radiologic outcomes, and clinical outcomes, and by the inconsistent reporting of the subjects included in a study population.

The results of the literature review are presented by each area for which evidence was sought.

Risk of Intracranial Injury

Ten published articles were identified that provided estimates of the prevalence of intracranial injury in children with mild head injury, with CT scans used as the "gold standard" (Table 1). Among these articles, however, 3 included patients with more severe symptoms or findings than specified by the guideline case description (including Glasgow coma scale [GCS] scores as low as 13),[1–4] and 1 included trivial abnormalities on CT as the principal outcome measure.[5] Among those studies restricting their subjects to GCS scores of 15, and considering abnormal findings to be subdural, extradural, or intracerebral hematomas, ranges of the prevalence of intracranial injury ranged from 0% to 7%.[3,6–9] The high estimate of 7% comes from a study in which both initial and delayed (24-hour) CT scans were obtained for most patients; how many patients were referred for care at this institution because of clinical deterioration was not noted.[8]

Three unpublished studies provided prevalence estimates of intracranial injuries ranging from 4% to 10% among patients with a GCS score of 15, without focal neurologic findings, but with either a history of (brief) loss of consciousness or amnesia (J. Finkelstein, 1994; S. C. Stein, 1994; S. C. Stein, 1994).

We sought to determine within these articles whether any clinical characteristics were associated with the presence or absence of significant CT scan abnormalities. Two studies indicated that among patients with a GCS score of 15, normal neurologic examinations, no history of loss of consciousness or amnesia, no vomiting, headache, or subtle changes in mental status, there were no abnormal CT scan findings.[1,7] One additional case series (49 children) found that no child with a GCS of 15, a completely normal neurologic examination, and no trauma aside from the head injury experienced an intracranial lesion, even with a history of loss of consciousness or amnesia.[9] The upper limits for the 95% confidene interval for this estimate is 6%, and the analysis that identified this group of predictors is exploratory; no confirmatory analyses were undertaken in a second dataset.

One pediatric study used surgery for intracranial bleeding as an indicator of intracranial injury. This study found that .017% of cases with a GCS score of 15 required surgery.[10]

We conclude from these data that:

- the true prevalence of intracranial injury following mild head injury is not clearly known;

- the population as defined by the head trauma task force is likely heterogeneous in its risk;
- children with clinically trivial head injury—no loss of consciousness or amnesia, normal examinations, no vomiting, headache, and a GCS score of 15—are at substantially <1% risk of having an intracranial abnormality of immediate clinical significance;
- children with mild head injury but who have experienced loss of consciousness, amnesia, vomiting, or seizures are at higher risk of having an intracranial injury detected using CT, likely in the 1% to 5% range, with a significantly lower amount requiring any intervention (see below).

We extended this section of the literature review to examine the significance of the abnormalities detected by CT scanning in such patients (Table 2). No studies randomly assigned patients with abnormal CT scans to receive or not receive surgery. Rather, several reports on the management decisions among those children found to have abnormal CT scans. These studies, and the unpublished data provided to us, indicated that between 20% and 80% of children with abnormal CT scans underwent a neurosurgical procedure, a proportion of which was intracranial pressure monitoring only.

Imaging Modalities

Through the 1970s and early 1980s, controversy raged concerning the role of skull radiography in the assessment of acute head trauma. Although fewer articles are now being written on this topic, the lack of access to CT scanners in some practice settings prompted review of this literature.

We identified 5 studies that examined the sensitivity and specificity of skull radiographs for the detection of intracranial injury, using intracranial abnormality or bleeding as determined by CT scanning as the gold standard. (Table 3). These studies found that the sensitivity of skull films varied from 50% to 100%; 1 of the studies showing 100% sensitivity was restricted to adolescents. The specificity of skull films for intracranial injury (ie, the proportion of patients without intracranial injury who have normal films) has been reported to be between 53% and 97%. Thus, a substantial proportion of patients without intracranial injury will have abnormal skull films.

A few studies have examined the role of MRI in head trauma.[11–17] These studies indicate that although subtle forms of neural injury can be better detected by MRI, and that isodense subdural collections (as may be found in chronic subdural injuries in adults) also may be more readily identified, in acute settings with children MRI offers no advantage in detecting lesions of clinical concern.

TABLE 2. Mild Head Trauma: Need for "Treatment" If CT Is Abnormal

First Author	Cite	Year	Design	*n*	Estimate
Knuckey	34	1989	Case series	8	25%
Rosenthal	3	1989	Case series	6	50%
Chan	38	1990	Case series	10	80% receive surgery 40% receive emergency surgery (20% receive no treatment)
Hennes	1	1988	Case series	6	33% receive surgery
Rivara	2	1987	Case series	49	25% receive therapy 12.5% receive surgery (rest = bolt)
Stein	Unpublished	1993	Case series	56	20% receive neurosurgical procedure
		1993	Case series	163	61% receive neurosurgical procedure
Pang	41	1983	Case series	11	18% receive surgery
Immordino	30	1986	Case series	3	0
Hahn	8	1993	Case series	42	0 patients with punctate or ring hemorrhage had adverse outcome
Schunk	32	1996	Case series	7	43% (3/7)
Children and adults combined					
Shackford	36	1992	Case series	468	31.8% receive treatment 20.9% receive surgery

TABLE 3. Mild Head Trauma: Sensitivity/Specificity of SXR for Intracranial Injury

First Author	Cite	Year	Design	Outcome	*n*	Prevalence	Sensitivity	Specificity
Rosenthal	3	1986	Case series	IC complication	358	1.7%	100	87
Royal College of Radiologists	37	1983	Case series	IC bleeding	1907	.1%	50	
Zimmerman	31	1978	Descriptive	Significant IC abnormality	144	?	69	68
Chan	38	1990	Case series	IC hematoma	418	3.1%	100	97
Hahn	8	1993	Case series	IC hematoma	791	8.5%	73	53
Children and adults mixed								
Masters	39	1980	Case series	Intracranial sequelae	1845	1.8%	21	96
Pre-CT data								
Teasdale	10	1990	Case series				62	

IC indicates intracranial.

We conclude from this literature that 1) although an abnormal skull film increases the likelihood of a significant intracranial lesion, the test is not of sufficient sensitivity or specificity to be clinically useful in most settings, and 2) CT is sufficiently sensitive and specific as the imaging modality of choice at this time; in most cases, a normal CT scan in a child who meets the case definition provides assurance that subsequent adverse outcomes are very unlikely. A cohort of 399 such children (GCS >12 and normal CT scan) found 3 patients who were readmitted within 1 month, 1 of whom had an intercranial contusion, but none required neurosurgical intervention. Rarely, cases are reported in the literature of children with normal CT scans who subsequently develop "flash edema," or, even more rarely, intracranial (especially epidural) hematomas.[18]

Utility of Early Diagnosis

In the course of the literature review, because the reviewers identified several papers and unpublished reports that noted a higher frequency of intracranial abnormalities than the subcommittee members had anticipated, the subcommittee requested that literature examining the utility of the early diagnosis of these abnormalities be examined (Table 4). Little child-specific data are available that relate to this question, ie, "Are children with apparently mild head trauma who are discovered to have an intracranial injury better off if the discovery is made sooner rather than later?" Although a classic and often cited study of comatose adults with subdural hematoma showed a dramatic benefit associated with rapid diagnosis and treatment,[19] subsequent study has not replicated that report for either subdural or epidural bleeding.[20–22] Small case series have similarly not found a correlation between delay in diagnosis of intracranial bleeding and outcome in children.[23] The extreme limitations of these reports in their sample size, and the appropriately nonrandom allocation of time to diagnosis and treatment make any inferences from this work extremely limited.

Effectiveness of Alternative Management Strategies

An ideal study seeking to determine the relative effectiveness of alternative management strategies would initially define a homogeneous population of children with mild head trauma, and randomly assign such children to 1 of 2 or more potential approaches. Such approaches might include inpatient observation for a defined period of time without initial imaging, outpatient observation without imaging, or CT scanning followed by outpatient observation if scans are normal. No such study has been identified in the pediatric literature. The rarity of adverse outcomes would make such a study difficult to perform, and would require careful collaboration across multiple institutions.

One decision analysis has been published that assesses the cost-effectiveness of a particular strategy for the evaluation of head trauma.[24] This analysis, although not limited to children, utilized much pediatric data in developing the probabilities required for the analysis. The authors recommend immediate

TABLE 4. Mild Health Trauma Impact of Delay on Outcome

First Author	Cite	Year	Design	Outcome	Estimate	*n*	Comments
Sainsbury	23	1984	Case series (record review)	Impairment	0/7 patients with mild injury whose diagnosis of ICH delayed >24 h had impairment 1/7 patients with head injury diagnosis of ICH delayed 5–24 h died		If disease severe, diagnosis made quickly (excluding intentional injury) 2 patients seen early (<2 h), discharged, and returned; 2 patients admitted and diagnosis made later; 2 patients presented late; unclear which patient died (1 missing)
Snoek	18	1984	Case report	Death	1/780 patients with AIS 1 or 2		Girl discharged home normal, returned "several" hours later and died; no mass by angiography (CT not applicable)
Children and adults together; includes moderate and severe							
Chen	20	1993	Case series (extradural hematoma)	Operation	No relationship delay (< or >6 h) on need for surgery	74, GCS >12	Mean age 25 y, distribution not given
Lobato	22	1991	Case series (patients who deteriorate)	Death	No correlation delay in diagnosis with eventual outcome	211	Children more likely to have diffuse swelling (39%) or epidural (29%)
Hatashita	21	1993	Case series (subdural hematoma)	Death	No relationship delay on outcome (within 10 h)	60	No children in GCS 7–14 group; GCS best predictor of outcome.
Seelig	19	1981	Case series (subdural hematoma, coma)	Death	<4 h = 30% >4 h = 90%	82	All patients comatose; mean age 41 y; not replicated

ICH indicates intracranial hematoma.

CT scanning for patients with abnormal clinical signs; for patients who are otherwise normal, these authors recommend skull radiography, with CT if radiographs are abnormal. If such a strategy were followed for 10 000 persons presenting with mild head trauma, of 10 000 individuals with head injuries, the 9900 additional skull films and 250 CT scans would identify 6 or 7 additional cases of early intracranial hemorrhage.

Outcome of Mild Head Trauma

In an idealized decision analytic framework, the "utilities" to patients of the various clinical outcomes are incorporated in assessing the value of each potential treatment arm. We sought to identify through the literature the long-term outcome for the index case, assuming no significant intracranial abnormalities were identified.

Several studies did not specifically report on outcomes for pediatric patients, although authors typically commented that outcomes for children were better than those for adults.[25] Four studies, however, did specifically examine outcomes for children. One large cohort study of children with "minimal" (or "trivial") head injury, ie, excluding children with skull fracture, loss of consciousness, or having been admitted to an inpatient unit, found physical health 1 month after injury to be identical to that of a normal population, but that role limitations, eg, school absenteeism, was substantially increased.[26] Unfortunately, this study could not distinguish whether this effect was the result of the head injury, or associated either with the use of the emergency department or with whatever factors led to the injury. A smaller study of children with mild injury including "concussion" found a slight increase in teacher-reported hyperactivity (activity and inattentiveness) 10 years after the injury, with no other differences in school performance, cognitive ability, or behavioral symptoms. In this relatively small cohort, no differences in these outcomes between those patients who had been observed in inpatient or outpatient settings were identified.[27] Two more recent studies also suggested some possible long-term impact of head injury. Comparing a cohort of 95 children followed up 1 year after hospitalization for head trauma of varying degree with population norms, investigators found that the children with head injuries had higher levels of physical and behavioral impairment; this investigation did not control for preexisting morbidity leading to the injury.[28] Only patients at the most severe end of the spectrum (Abbreviated Injury Scale level 5) had demonstrably worse outcomes than those with milder injuries (Abbreviated Injury Scale level 2). A more compelling study from New Zealand compared children ages 2½ to 3½ years of age with mild head trauma (evaluated in an emergency department but not admitted to the hospital) with injury date-matched children with other forms of mild trauma 1, 6, and 12 months after the injury and when the children were 6½ years of age.[29] The investigators found specific deficits in solving visual puzzles beginning 6 months after injury and persisting throughout the observation; these children were also more likely to have reading disabilities. We conclude from these investigations that children who present with head injuries or other types of injuries are different from the general population and more likely to have some functional impairment unrelated to the injury per se; at the same time, children with mild or minimal head injury may be more likely to experience subtle abnormalities in specific cognitive functions.

CONCLUSION

The literature on mild head trauma does not provide a sufficient scientific basis on which clinical management decisions can be made with certainty. The field remains burdened by inconsistent definitions of case severity, inadequate specification of the population base, and varied and incomplete definition of outcome.

Nonetheless, the published data do indicate that 1) a small proportion of children with minimal and mild head injury will have significant intracranial injury; 2) the presence of either loss of consciousness or amnesia increases the probability that an injury is present in many, but not all studies; 3) CT scanning is the most sensitive, specific, and clinically safe mode of identifying such injury, whereas plain radiographs in this pediatric age group have neither sufficient sensitivity nor specificity to recommend their general use; 4) extremely rare children with normal examinations and CT scans will experience delayed bleeding or edema; and 5) long-term outcomes for children with minimal or mild head injury, in the absence of significant intracranial hemorrhage, are generally very good, with a suggestion of a small increase in risk for subtle specific deficits in particular cognitive skills.

The confusion in this field mandates that multicenter, collaborative investigations be performed that will begin to address the limited information base on which such a large volume of clinical care rests.

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