Skull Fracture and the Low Risk of Intracranial Sequelae in Minor Head Trauma

John R. Thornbury, John A. Campbell, Stuart J. Masters and Dennis G. Fryback

AJNR Am J Neuroradiol 1984, 5 (4) 459-462
http://www.ajnr.org/content/5/4/459

Skull Fracture and the Low Risk of Intracranial Sequelae in Minor Head Trauma

John R. Thornbury[1]
John A. Campbell[2]
Stuart J. Masters[3]
Dennis G. Fryback[4]

The presence of skull fracture has been associated with a higher risk of intracranial sequelae than if a fracture were not present. This is true for the total population of head-injury patients. However, reanalysis of the patient selection criteria data from two large published series on skull imaging in head trauma revealed that this increased risk factor for intracranial sequelae did not apply to a specific subset of minor-head-trauma patients. The patients in this subset were characterized by the presence of one or more of five "low-yield" criteria: (1) asymptomatic (no complaints), (2) headaches, (3) dizziness, (4) scalp hematoma, and (5) scalp laceration. All other criteria were absent. Results of the reanalysis showed (from a total population of 3031 head-trauma patients) a subset of 1184 patients characterized by these five criteria. In these 1184 minor-head-trauma patients there were 19 fractures, all linear, with none depressed or basilar. There were no intracranial sequelae. This change in the concept of fracture as a risk factor for intracranial sequelae has major implications in the future development of strategies for selecting patients for *not* having skull films or head computed tomograms.

In 1979 and 1980, respectively, DeSmet et al. [1] and Masters [2] shifted the emphasis in diagnostic imaging of head-trauma patients away from identification of skull fracture as an end point to the diagnosis of intracranial sequelae [1, 2]. Masters pointed out that most patients with intracranial sequelae do not have skull fractures and that most patients with fractures do not sustain intracranial sequelae (table 1). In view of the poor correlation of skull fractures with significant intracranial sequelae, Masters suggested that, for a select subgroup of patients, skull fractures actually may protect against significant intracranial sequelae. Therefore, he questioned the value of skull radiography in evaluating head injuries and urged a shift to computed tomography (CT) of the head when clinical suspicion warranted imaging.

It is generally accepted that the presence of intracranial sequelae is greater in patients with skull fractures than in patients without skull fractures [3, 4]. This concept has been a major factor in spurring physicians to request skull radiography in patients with head trauma regardless of either how serious or how minor the injury appears. The nagging fear of "missing the fracture" by not requesting skull radiography has been exaggerated further by the sense that the patient was at greater risk for intracranial injury because of the possibility of having a missed fracture.

In considering Masters's data about the incidence of fractures and intracranial sequelae and sequelae in patients without fracture, it struck us that there must be some subset of all head-trauma patients in whom fracture occurred, but there was little if any incidence of intracranial sequelae. What might distinguish these patients? Very likely, they would be patients in whom the force and mechanism of the head injury was sufficient to cause a fracture, but not sufficient to cause intracranial injury.

We then wondered how we could identify the minor-head-injury patient to determine if fracture did or did not have an increased risk of intracranial sequelae.

This article appears in the July/August 1984 issue of *AJNR* and the September 1984 issue of *AJR*.

Received November 28, 1983; accepted February 2, 1984.

[1] Department of Radiology, University of New Mexico Hospital, Albuquerque, NM 87131. Present address: University of Rochester Medical Center, Rochester, NY 14642. Address reprint requests to J. R. Thornbury.

[2] Department of Radiology, University of Southern California, School of Medicine, Los Angeles, CA 90033.

[3] Department of Radiology, Berkshire Medical Center, University of Massachusetts, Pittsfield, MA 01201.

[4] Department of Industrial Engineering, University of Wisconsin/Madison, Madison, WI 53706.

***AJNR* 5:459–462, July/August 1984**
0195–6108/84/0504–0459 $2.00

TABLE 1: **Association of Skull Fracture and Intracranial Sequelae**

Skull Fracture	Intracranial Sequelae		
	Present	Absent	Total
Present	7	72	79
Absent	26	1740	1766
Total	33	1812	1845

Note.—Data were compiled from the study of Masters [2].

TABLE 2: **Incidence of Fractures and Intracranial Sequelae with Selected Low-Yield Criteria**

Low-Yield Criterion	No. Patients (%)		
	Totals	Fractures	Intracranial Sequelae
Asymptomatic (no complaints)	788	24 (3)	1 (<1)
Headaches	333	13 (4)	5 (2)
Dizziness	43	2 (5)	0
Scalp hematoma	443	30 (7)	5 (1)
Scalp laceration	768	34 (4)	12 (2)

Note.—These patients were from 1845 studied by Masters [2].

Since the trauma forces are likely to be lower in the minor-head-injury subgroup, then the yield of fractures also should be low. It happened that there were published data ranking patient selection criteria into high- and low-yield categories in regard to fracture detection and incidence of intracranial sequelae. Masters's 1980 report included a specific table listing low-yield criteria [2].

Materials and Methods

We reviewed Masters's low-yield table, and five patient selection criteria were chosen on the basis of four qualifications: (1) the yield of fracture was relatively low; (2) the yield of intracranial sequelae was very low; (3) the number of those patients having that criterion was relatively high; and (4) the criterion was one commonly encountered among patients seen in the emergency room for head trauma. This resulted in an arbitrary list of five selection criteria that seemed to be representative of patients suffering trivial or minor trauma: (1) asymptomatic (no complaints), (2) headaches, (3) dizziness, (4) scalp hematoma, and (5) scalp laceration (table 2).

We then decided to reanalyze the Masters's data looking at the subset of patients having only one or more of these five low-yield criteria. We wished to answer two questions for this subset of patients: (1) What is the incidence and type (depressed, basilar, or simple) of fracture? and (2) What is the incidence of intracranial sequelae?

We also had access to a similarly constructed original data base from a report about efficacy of skull radiography in fracture detection, which also included outcome information about incidence of intracranial sequelae [5]. This was published in 1981, and one of the authors (J. A. C.) had access to the original IBM data cards for 1186 of the original 2021 patients.

Reanalysis of these two data bases was aimed at answering the two basic questions posed above. One of us (D. G. F.) analyzed the Masters's data at the University of Wisconsin. The data from Balasubramaniam et al. [5] were analyzed at the Drew Medical Center in Los Angeles by J. A. C.

The original IBM cards for the Masters's data were provided to D. G. F. The computer analysis approach used was to select a subset of the 1845 patients. This subset was characterized by absence of all the criteria (high- or low-yield) *except* for presence of one or more (in any combination) of the five low-yield criteria listed above. The incidence of fracture (and breakdown into types) and the incidence of intracranial sequelae were determined to answer the two questions we had posed. The original data cards from Balasubramaniam et al. [5] were analyzed in the same way.

TABLE 3: **Incidence of Fractures and Intracranial Sequelae**

No. of Patients:	Reference	
	[2]	[5]
Studied	1845	1186
With one or more of five low-yield criteria	499	685
With fractures	8	11
With intracranial sequelae	0	0

Results

The results are shown in table 3 for data from both studies [2, 5]. The proportion for each data base of the total patient population constituting the low-yield-criteria patient groups was 499 (27%) of 1845 for Masters and 685 (57.7%) of 1186 for Balasubramaniam et al. While there were a few fractures in each group, eight (1.6%) of 499 and 11 (1.6%) of 685, there were no intracranial sequelae. Furthermore, all the fractures were simple. None were depressed or basilar.

As a double check on intracranial sequelae, the patients who had intracranial sequelae were analyzed as to each patient's mix of criteria. No patient was found to have *only* low-yield criteria.

Discussion

Three important conclusions can be drawn from this retrospective reanalysis: First, in the presence of a skull fracture, no increased risk of intracranial sequelae was found in this low-yield-criteria subgroup of all head-trauma patients. Second, if these five low-yield criteria had been used to select patients *not* to have skull radiography, no intracranial sequelae would have been missed. Third, when fractures did occur, these were simple and not depressed or basilar.

At about the time of our reanalysis, the Royal College of Radiologists [6] published a report that dealt with patient selection for skull radiography in the subset of all head-trauma patients defined as having "uncomplicated head injury." This report was based on a large-population, multiple-institution survey of current skull radiography practice in the United Kingdom. Earlier reports on the total patient population had been published in *Lancet* [7, 8]. The important point about these papers was the conclusion: "Patients with complicated head injury should be regarded as a separate group because their risk of skull fracture and serious outcome . . . is substantially greater than that in those with uncomplicated injury" [6]. The definition of uncomplicated head injury: Patients who had head injury but did not have coexisting conditions, including other fractures or external injury, road accidents where the major injury or disorder was unclear, disturbed mental state, other acute disorder, or chronic disease that may influence subsequent patient management.

In the 4829 patients in the Royal College study with uncomplicated head injury, a subgroup of 3328 patients was classified as "clinically negative." Clinically negative meant absence of cerebrospinal fluid and/or blood discharge from the nose, hemotympanum and/or fluid discharge from the ear, unconsciousness at any time, altered state of consciousness at time of examination, and other focal signs or symptoms. The incidence of intracranial sequelae was one in 3328 in this clinically negative subgroup. There were 23 linear vault fractures, but there were no basilar or depressed fractures.

Combining the reanalysis results from the data of Masters [2] and Balasubramaniam et al. [5] yields 3031 head-trauma patients of whom 1184 can be classified as minor-head-injury patients as selected on the basis of the five low-yield criteria. Only 19 simple linear fractures occurred. There were no basilar or depressed fractures. Most important of all is that no intracranial sequelae occurred, whether a fracture was present or not.

This "nonoccurrence" of the most serious consequence of head trauma, brain injury, presents an interesting statistical problem. We know that in 1184 selected patients there were no intracranial sequelae. The multiinstitutional study of the Royal College of Radiologists yielded similar findings. There was one intracranial sequela in the subgroup of 3328 clinically negative patients. However, we do not know if that one patient would have satisfied the low-yield criteria for the selection of our patients. Interestingly, all 23 fractures they detected were linear, and as in our cases, none of the fractures were depressed or basilar.

Their *clinically negative* is different from our *low-yield/minor-head trauma.* Nevertheless, the results suggest that the two groups are fairly similar. On the basis of our results and theirs, we estimate that in a hypothetical population of patients having minor head trauma, the incidence of intracranial sequelae would be in the range of one in 3000–5000. Furthermore, we would expect the fractures to be linear, not depressed or basilar.

The point about the type of fracture is relevant to treatment considerations. If fragments of a simple depressed fracture extend more than 0.5 cm in depth, neurosurgeons recommend that they be elevated if the depressed fragments overlie the motor strip or speech area [9]. Another surgical rule of thumb: Depression of fragments greater than the thickness of the skull should be elevated [10]. Depressed fractures of the open ("compound") type are almost always debrided [9].

If a fracture is basilar in location, patients may be admitted for observation and given antibiotic therapy [2]. These two types of fractures (depressed and basilar) are usually diagnosed clinically, but occasionally require skull radiography. The results of our reanalysis indicate that this should be of no concern. No depressed or basilar fractures were found in any of the patients [2, 5] who had only low-yield criteria. Fractures occurred but were simple.

One of the implications of our reanalysis is that our five low-yield criteria could be used to select patients for *not* doing skull radiography or head CT imaging. If this decision rule had been used in the 3031 patients having skull radiology in the combined data bases, 1184 (39.1%) would not have been imaged. While fractures did occur in this potentially "nonimaged" group and would have been "missed," these were innocuous fractures. No basilar or depressed fractures would have been missed. Most important, no intracranial sequelae would have been missed. Further, reanalysis of our data has turned up no instance of intracranial sequelae.

It has been argued that anything can be proved with statistics. Our reanalysis was a retrospective after-the-fact assignment of clinical clues in patients' medical records to well defined specific categories of "selection criteria," which are meant ultimately to be usable prospectively.

For these reasons, we do not recommend that physicians rush to apply our five criteria in a simple triage strategy for head imaging in trauma patients. This clinical application requires thoughtful and careful consideration of how our five criteria should be considered in the overall assessment of all the selection criteria that have been published (for instance, in Masters's article [2]).

In fact, a thorough review of patient selection for head imaging in trauma patients is being conducted by a multidisciplinary panel of experts. The panel's work is sponsored by the former Bureau of Radiological Health and the University of California Radiological Health Sciences Project. The report and recommendations of this panel will be completed (including review by appropriate specialty groups) in mid or late 1984.

The report will examine both objective patient selection criteria from the literature and subjective physicians' judgments about the decision regarding whether or not to request skull radiographs or head CT examinations on head-trauma patients. Its recommendations will consider identifying clinical situations in which the selection criteria lose their usual predictive values. The aim is to optimize use of head-imaging examinations while not degrading the detection of complicated fractures and intracranial sequelae beyond reasonable risk levels.

Our review and reanalysis do not dispute the general belief that skull fractures have an increased risk for intracranial sequelae when *all* head trauma patients are considered. What we have discovered is that there is a substantial subgroup (arbitrarily defined by our five low-yield criteria) in which fracture does not increase the risk of intracranial sequelae.

This discovery has potential major impact on the development of patient sorting strategies based on patient outcome of intracranial sequelae. We urge other investigators with data-base information similar to the patient groups we studied [2, 5] to reanalyze their data as we have to confirm or refute our findings. More extensive reanalysis could also be used to look for other low-yield factors that would extend the size of the low-yield/minor-trauma patient group. The aim would be to determine the threshold combination of low-yield fractures at which complicated fracture and intracranial sequelae first occur.

REFERENCES

1. DeSmet AA, Fryback DG, Thornbury JR. A second look at the utility of radiographic skull examination for trauma. *AJR* **1979**;132:95–97
2. Masters SJ. Evaluation of head trauma: efficacy of skull films. *AJR* **1980**;135:539–547
3. Galbraith S, MacMillan R, Jennett B. X-rays for skull fracture. *Lancet* **1981**;1:272
4. Jennett B. Skull x-rays after recent head injury. *Clin Radiol* **1980**;31:463–469
5. Balasubramaniam S, Kapadia T, Campbell JA, Jackson TL. Efficacy of skull radiography. *Am J Surg* **1981**;142:366–369
6. Royal College of Radiologists. Patient selection for skull radiography in uncomplicated head injury. *Lancet* **1983**;1:115–118
7. Royal College of Radiologists. A study of the utilisation of skull radiography in 9 accident-and-emergency units in the U.K. *Lancet* **1980**;2:1234–1236
8. Royal College of Radiologists. Costs and benefits of skull radiography for head injury. *Lancet* **1981**;2:791–795
9. Keller TS, Schneider RC. Simple depressed fracture in craniocerebral trauma. In: Schneider RC, Kahn EA, Crosby EC, Taren JA, eds. *Correlative neurosurgery*, vol 2, 3d ed. Springfield, IL: Thomas, **1982**:1319–1321
10. Miller JD, Jennett WB. Complications of depressed skull fracture. *Lancet* **1968**;2:991–995