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A retrospective review of 1,845 patients was performed to evaluate the efficacy of skull films in acute head trauma. The implications of efficacy included effects on diagnosis, therapy, and ultimate outcome. Seventy-nine patients had skull fractures. Thirty-three patients sustained significant intracranial sequelae from their injuries, but only seven of these also sustained fractures. Twenty-six patients had significant intracranial sequelae but no skull fracture. In none of the 33 patients with significant intracranial sequelae was management or outcome affected by skull film findings. Of 1,845 patients, seven (0.38%) had basilar fractures requiring antibiotics. These were the only patients whose treatment and outcome were apparently altered by radiographic findings. Skull fractures alone seldom indicate more serious internal head injury. Routine skull films after head trauma are not effective contributors to the evaluation, management, or outcome of acute intracranial injury. "High-yield" clinical criteria are offered for predicting patients at risk for significant intracranial sequelae. If any of the "high-yield" features for significant intracranial sequelae are present, computed tomography should be considered as the primary, noninvasive diagnostic procedure of choice. The poor correlation of skull fracture with significant intracranial sequelae suggests that, for a select subgroup of patients, skull fracture may protect against significant intracranial sequelae.

In the evaluation of head trauma, skull films have reached a level of use that is almost automatic. In most emergency rooms in the USA, skull series are routinely requested after head injury regardless of historical, physical, or neurologic findings. The usual explanation for ordering a skull examination after acute trauma is that there may be an unsuspected fracture. Occasionally the explanation is fear of medicolegal repercussion (14.3% of referring physicians listed "medicolegal" as their reason for skull films in the recent American College of Radiology efficacy study [1]). More recently, educated patients attuned to modern standards of medical practice have requested or even demanded radiographs after trauma to the head.

It is generally accepted that demonstration of a depressed or basilar fracture may alter patient management. The former may need surgical elevation of the depressed fragment while the latter requires antibiotic therapy. In contrast to depressed and basilar fractures, simple fracture of the skull without complication needs no specific treatment. In many hospitals, patients with simple skull fracture are discharged from the emergency room with a *head sheet* and appropriate instructions to family members, who will observe the patient at home. (In the absence of reliable observers at home, a patient with simple fracture may be admitted for observation.)

The recent American College of Radiology efficacy study defines three important levels of efficacy [1]: (1) *diagnostc efficacy* influences physicians' thinking; (2) *treatment efficacy* influences management; and (3) *long-term efficacy* influences outcome. Confirmation of clinical impression (diagnostic efficacy) is regarded as an important and intrinsically sufficient reason for radiography. That

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is, confirmation of an opinion frequently enables the clinician to terminate further investigation and observation of the patient. If the clinician initially suspects fracture and finds none by radiography, the patient may be saved time, money, and the inconvenience of unneeded further testing or therapy. The result is the same if the initial clinical impression of "no fracture" is subsequently confirmed by radiography.

The concept of a diagnosis of "normal" contributing to efficacy is not entirely new. It does mean that efficacy has become a much more complex term to evaluate. The studies by Bell and Loop [2] and more recently Phillips [3] were basically studies of the efficacy of fracture detection. However, the more important purpose in evaluating head trauma should be to detect what, if any, significant intracranial abnormalities have occurred, or will likely occur, as a direct effect of the injury. If the patient sustains a skull fracture, does this imply an increased risk of significant intracranial sequelae? (*Significant intracranial sequelae* comprise any intracranial hemorrhage, whether subdural or epidural hematoma, brain contusion, or brain laceration.) Or is there, perhaps, little or no correlation between fracture and significant intracranial sequelae?

This efficacy study of skull films was designed to determine whether plain skull films help direct management or affect outcome in patients sustaining head trauma—specifically, in patients sustaining significant intracranial sequelae from head injuries. The impetus for the study derives from my experience as head of the Emergency Division of Diagnostic Radiology at Yale–New Haven Hospital, where 3,154 skull examinations were performed in 1974. It became apparent that the incidence of positive skull findings was very low. The yield of findings that helped direct management or outcome was even lower, prompting a personal interest in efficacy and the current study. In designing the coding taxonomy for the study, the approach of Bell and Loop [2] in identifying "high-yield" criteria was applied both to the number of fractures and significant intracranial sequelae. However, this study was aimed primarily at treatment and long-term efficacy and only secondarily at diagnostic efficacy.

Materials and Methods

The 1,845 patients who had skull examinations for head trauma during 1974 are the subjects of this study. Other patients who had skull examinations for seizures, headaches, and other clinical problems unrelated to trauma were not included.

Data collection began with review of the emergency room sheet on each patient, followed by similar review of all subsequent data in the hospital record. The data collected comprised age, gender, date and type of injury, history, physical and neurologic findings, vital signs, skull examination findings, findings on accompanying films about the head and neck, impressions in the emergency room, disposition in the emergency room and in the hospital (i.e., angiography or neurosurgical procedure), final diagnosis at discharge or death, follow-up diagnosis and duration of follow-up, and cause of death if it occurred.

Skull films were reviewed on all patients with significant intracranial sequelae, except six that were unavailable during several attempted reviews over a 2-year period. Finally, data were submitted for computer analysis.

Results

Diagnostic Efficacy

There were 1,845 skull examinations for evaluation of head trauma. Of these, 79 patients (4.3%) had fractures and 33 (1.8%) sustained significant intracranial sequelae. Seven of the 33 patients with significant intracranial sequelae had skull fractures; 26 did *not*. Of the seven fractures, five were simple, one was depressed, and one was basilar.

In examining the records for history, and physical and neurologic examination, extensive data were collected. For example, amnesia was subdivided into retrograde, perifactual, and antegrade. Altered consciousness was subdivided into confusion, irritability, lethargy, short attention span, responsive to oral commands, responsive only to pain, unresponsive to pain, and stupor-semicoma or obtunded.

Tables 1 and 2 show the relative predictive values of parameters of history and physical and neurologic examination for skull fracture and significant intracranial sequelae. Table 1 shows the "high-yield" features—features with at least a 10% correlation to skull fracture or significant intracranial sequelae. Table 2 lists "low-yield" features. Some high-yield features include subcategories that are not high-yield. For example, under "Neurologic examination," "visual dysfunction" is high-yield overall, but its subgroup, "anisocoria," is not high-yield, with a predictive value of only 6% for significant intracranial sequelae. Also note that "confusion" appears twice in table 1, once as history of confusion and once as a component of the neurologic examination.

The only items under "history" that are high-yield for predicting significant intracranial sequelae are "unconscious: 10 min or longer," "confusion," "penetrating wound," and "seizure: acute or acute plus chronic." Other than a few physical findings that correlate as high-yield for skull fracture, physical findings show low predictive value for skull fractures and, more importantly, for significant intracranial sequelae. Neurologic abnormalities, however, are seen as excellent predictors of significant intracranial sequelae.

Vital signs were incompletely recorded in many patients' charts. In 1,038 patients with pulse recorded and in 1,071 patients with systolic blood pressure recorded, 2% and 3% respectively, sustained significant intracranial sequelae. It is notable that 9% and 11% of patients with pulse below 60 beats/min and systolic pressure below 100 mm Hg, respectively, sustained significant intracranial sequelae, indicating the importance of low pulse and low blood pressure.

"Intoxication" (table 2) includes several measured alcohol levels and alcohol on the breath. Similarly, there were subdivisions such as irregular breathing and Babinski reflex (unilateral/bilateral) that did not add significant information and were therefore grouped.

Table 3 shows findings on skull examinations in the 33 patients with significant intracranial sequelae. Note that 26

TABLE 1: **Predictive Value of Clinical Parameters for Skull Fractures or Significant Intracranial Sequelae: High-Yield Features**

Clinical Parameter	No. Patients (%)		
	Totals*	Fractures	Sequelae
History:			
Unconscious:			
10 min or longer	31	8 (26)	12 (39)
Of uncertain duration	136	14 (10)	8 (6)
Subtotal	167	22 (13)	20 (12)
Confusion	45	3 (7)	6 (13)
Penetrating wound	2	1 (50)	1 (50)
Seizure: acute or acute plus chronic	40	1 (2)	5 (12)
Physical examination:			
Palpable bony malalignment	21	8 (38)	2 (9)
Ear discharge	32	6 (19)	2 (6)
Nasal discharge	39	5 (13)	1 (3)
Black eye(s)	84	10 (12)	2 (3)
Neurologic examination:			
Altered consciousness;			
Confusion, lethargy, irritability	56	9 (16)	6 (11)
Responsive to pain	3	1 (33)	3 (100)
Unresponsive to pain	20	3 (15)	8 (40)
Miscellaneous and unspecified	29	2 (7)	15 (52)
Subtotal	108	15 (14)	32 (30)
Amnesia:			
Retrograde	11	2 (18)	0
Retrograde plus perifactual	6	2 (33)	1 (17)
Subtotal	17	4 (24)	1 (6)
Irregular breathing	10	3 (30)	7 (70)
Babinski positive	21	6 (29)	5 (24)
Abnormal deep tendon reflexes:			
Increased	5	1 (20)	3 (60)
Decreased	14	0	2 (14)
Absent	10	3 (30)	3 (30)
Unspecified	3	1 (33)	0
Subtotal	32	5 (16)	8 (25)
Focal weakness	70	6 (9)	12 (17)
Miscellaneous sensory abnormality	28	4 (14)	4 (14)
Visual dysfunction:			
Anisocoria	16	2 (12)	1 (6)
Fixed and dilated	11	5 (45)	5 (45)
Anisocoria plus fixed	3	1 (33)	2 (67)
Other visual abnormalities	46	3 (7)	5 (11)
Subtotal	76	11 (14)	13 (17)
Miscellaneous cranial abnormalities	29	4 (14)	7 (24)
Abnormal named reflex or sign	13	1 (8)	4 (31)
Other miscellaneous†	205	7 (3)	33 (16)

Note.—*High-yield* is defined as at least a 10% correlation between clinical parameter and fracture or significant intracranial sequelae.
* Totals represent total number of the 1,845 patients with specific feature.
† Includes unsteady gait, ataxia, cerebellar signs, etc.

of 33 patients with significant intracranial sequelae had *normal* skull films. Five of seven patients with skull fractures had *simple* fractures. There were no shifted pineal glands in this group, a surprising finding at least to the author. These data emphasize the insignificance of a normal skull film and midline pineal body in ruling out significant intracranial sequelae.

Treatment and Outcome Efficacy

Disposition in the emergency room for 1,845 patients with head injury appears in table 4. Two patients with significant intracranial sequelae left the hospital after initial examination, one against medical advice. The other was not believed to have any significant injury and was discharged. If the high-yield features for predicting significant intracranial sequelae (table 1) had been used, the second patient would have been suspected of possible intracranial injury because of unconsciousness and increased deep tendon reflexes and might have been admitted for observation. One can only speculate whether her deterioration would have begun during the period of observation (instead of after discharge), possibly leading to life-saving intervention.

Of 1,845 patients with head injury, 238 (13%) were

TABLE 2: **Predictive Value of Clinical Parameters for Skull Fractures or Significant Intracranial Sequelae: Low-Yield Fractures**

Clinical Parameter	No. Patients (%)		
	Totals*	Fractures	Sequelae
History:			
No complaints	788	24 (3)	1 (<1)
Unconscious less than 10 min	129	3 (2)	1 (<1)
Vomiting	138	12 (9)	7 (5)
Headaches	333	13 (4)	5 (2)
Visual disturbance:			
Blurring	43	2 (5)	0
Dizziness	44	4 (9)	1 (2)
Double vision	11	1 (9)	1 (9)
Combinations of above	34	1 (3)	0
Subtotal	132	8 (6)	2 (2)
Ear drainage (history of)	4	0	0
Physical examination:			
No abnormalities	542	12 (2)	12 (2)
Discolored eardrum/Battle sign	21	1 (5)	1 (5)
Intoxicated (or alcohol on breath)	179	7 (4)	2 (1)
Hematoma (scalp)	443	30 (7)	5 (1)
Laceration (scalp)	768	34 (4)	12 (2)
Neurologic examination:			
No abnormalities	1,495	48 (3)	0
Amnesia: perifactual	49	2 (4)	0

Note.—*Low-yield* is defined as a less than 10% correlation between clinical parameter and fracture or significant intracranial sequelae.
* Totals represent total number of the 1,845 patients with specific feature.

TABLE 3: **Skull Film Findings in Patients with Significant Sequelae**

Finding	Calcified Pineal (No. Patients)				
	Midline	Absent	Uncertain*	Shifted	Total
Normal skull	0	21	5	0	26
Simple fracture	2	2	1	0	5
Basilar or depressed fracture	0	2	0	0	2
Total with sequelae	2	25	6	0	33
Total population	156 (8%)	966 (52%)	720 (39%)	3 (<1%)	1,845 (100%)

* Films unavailable on several attempts spaced over 2 years. Since reports do not mention pineal, it is most likely absent or midline.

TABLE 4: **Emergency Room Disposition**

Disposition	No. Patients (%)		
	Total	Fractures	Sequelae
Admitted: no other study	208	33 (42)	13 (39)
Carotid or vertebral angiography or neurosurgical procedure	30	7 (9)	18 (55)
Unspecified and other	1	0	0
Died in emergency room	2	0	0
Discharged	1,604	39 (49)	2* (6)
Total	1,845	79 (100)	33 (100)

* One patient left against medical advice and was dead on arrival 5 days later. The other was discharged despite increased deep tendon reflexes and returned 7 days later with subdural hematomas and herniation. It is not known whether there was additional injury in the iinterval. She died after craniotomy.

admitted to the hospital (table 4). Neuroradiologic studies and/or neurosurgical procedures were required in 30 of these. Nine of the 30 patients had normal skull films and no significant intracranial sequelae. Three of the 30 had skull fractures but no significant intracranial sequelae, four sustained both skull fractures and significant intracranial sequelae, and 14 had normal skull film examinations but sustained significant intracranial sequelae.

Table 5 lists angiography, neurosurgery, and outcome in 33 patients with significant intracranial sequelae as a function of plain skull film findings. Note that eight of the 11 neurosurgical procedures were performed on patients with normal skull films. A total of 17 patients had angiography; 13 of these had normal skull series. The survival data show nine of 13 deaths in patients with normal skull films; 12 (92%) of 13 if simple skull fractures are included. Only one

TABLE 5: **Significant Sequelae According to Skull Films: Management and Outcome**

Skull Film Finding	No. Patients		No. Procedures		Outcome, No. Patients	
	Total	With Procedures	Arteriography	Neurosurgery	Alive	Dead
Normal	26	14	13	8	17	9
Simple fracture	5	3	3	2	2	3
Basilar or depressed fracture	2	1	1	1	1	1
Total	33	18	17	11	20	13

TABLE 6: **Predictive Value of Skull Films for Intracranial Sequelae**

Skull Films	No. Patients		
	Alive	Dead	Total
Negative	17	9	26
Fracture	3	4	7
Total	20	13	33

Note.—Yates correction of chi-square: $\chi^2 = 0.42$; $p < 0.55$.

TABLE 7: **Distribution of Fractures, Sequelae, and Outcome vs. Duration of Follow-up**

Duration of Follow-up	No. Patients				
	Total	With fracture	With Sequelae		
			Alive	Dead	Total
None	572	17	0	1	1
1–2 days	31	6	0	6	6
3–7 days	83	2	1	3	4
8–30 days	156	10	5	3	8
1–3 months	108	6	5	0	5
4–6 months	102	6	1	0	1
6 months +	793	32	8	0	8
Total	1,845	79	20	13	33

of 13 patients who died had a depressed fracture. This patient's injury was considered so massive that no neurosurgical procedure was undertaken and he died the next day. Table 6 demonstrates the poor predictive value of skull film examinations for survival in 33 patients sustaining significant intracranial sequelae from head injuries.

Table 7 lists duration of follow-up for all patients with skull fractures and significant intracranial sequelae and correlates follow-up with outcome. A large number of patients (572) had no follow-up. In part, this reflects the emergency room's close proximity to major interstate highways and a transient patient population. Also, a large number of indigent patients use the emergency room and either move frequently or register with false names and addresses. (About 25% of follow-up questionnaires were returned by the post office as nondeliverable.)

Table 8 shows predictive value of clinical parameters for basilar or depressed skull fractures. The number of patients involved (seven and 12, respectively) is too small for statistical significance, but the table should become useful as other investigators add patients to the data base. (Perhaps some center will collate data on patients with basilar or depressed fractures from around the country. A potentially very useful group of predictive criteria could result.)

Of 13 deaths due to significant intracranial sequelae of head injuries, seven (54%) were within the first 48 hr and 10 (77%) occurred within 1 week. Of patients with skull fractures, 68% were followed for at least 1 week to rule out development of significant intracranial sequelae.

Other Information

Falling, usually on stairs, was the most common type of injury, accounting for 688 head injuries. There were 518 patients with head injuries from car accidents. The patient was in the front seat in 83% of the accidents, 50% of the time as driver. Beatings or fights injured 447 patients. There were 80 patients who were hit by a car, truck, or bus; 25% of them were on a bike. This group of 80 patients contained the highest frequency of skull fracture (10%) and significant intracranial sequelae (6%).

The monthly number of skull series for head trauma was 117–195 (mean, 154) with some summertime predominance. Fractures showed no particular seasonal trend. Occurence of significant intracranial sequelae seemed to peak during the warmest months but the numbers are too small to attain statistical significance.

Males had 58% of head injuries and 72% and 73% of skull fractures and significant intracranial sequelae, respectively. Most head injuries (60%) occurred during the first three decades of life as did the number of skull fractures (65%). The incidence of significant intracranial sequelae, however, is skewed toward patients over age 70.

Cervical spine films were obtained in 614 of the 1,845 patients with head injuries. Only six had fracture or subluxation, while 39 had straightening of curvature.

Discussion

A review of recent literature suggests that undue emphasis has been assigned to identifying simple skull fractures. In some hospitals, skull fractures cause the patient to be admitted but rarely affect management or outcome [4–9]. Perhaps the current era of efficacy studies began with the review by Bell and Loop [2] in 1971. In their excellent review by Bell and Loop [2] in 1971. In their efficacy study of skull films for trauma, they categorized "high-yield" findings from the patient's history and physical and neurologic examinations by their correlation with skull fractures. Since the original article, they and others (e.g., Phillips [3,10] have honed down the list of high-yield criteria

TABLE 8: **Predictive Value of Clinical Parameters for Basilar or Depressed Fracture**

Clinical Parameter	No. Patients (%)		
	Total	Type of Fracture	
		Base	Depressed
History:			
No complaints	788	1 (<1)	5 (<1)
Unconscious:			
10 min plus	31	0	1 (3)
Less than 10 min	129	2 (2)	0
Of uncertain duration	136	2 (1)	1 (1)
Subtotal	296	4 (>1)	2 (<1)
Uncertain if unconscious	171	0	2 (1)
Confusion	45	0	1 (2)
Penetrating wound	0	0	0
Seizure: acute or acute plus chronic	40	0	0
Vomiting	138	2 (1)	2 (1)
Headaches	333	1 (<1)	4 (1)
Visual disturbance:			
Blurring	43	0	1 (2)
Dizziness	44	1 (2)	0
Double vision	11	0	0
Combinations of above	34	0	0
Subtotal	132	1 (<1)	1 (<1)
Ear drainage, history of	4	0	0
Physical examination:			
No abnormalities	542	0	5 (<1)
Palpable bony malalignment	21	0	2 (10)
Ear discharge	32	3 (9)	0
Nasal discharge	39	2 (5)	0
Black eye(s)	84	0	1 (1)
Discolored eardrum/Battle sign	21	4 (19)	1 (5)
Intoxicated or alcohol on breath	179	0	0
Hematoma (scalp)	443	3 (<1)	2 (<1)
Laceration (scalp)	768	2 (<1)	6 (<1)
Neurologic examination:			
No abnormalities	1,495	3 (<1)	6 (<1)
Altered consciousness:			
Confusion/lethargy/irritability	56	0	2 (4)
Responsive to pain	3	0	1 (33)
Unresponsive to pain	20	0	2 (10)
Miscellaneous and unspecified	29	0	0
Subtotal	108	0	5 (5)
Amnesia:			
Retrograde	11	0	0
Retrograde plus perifactual	6	0	0
Extent unspecified	41	1 (2)	0
Subtotal	58	1 (<2)	0
Irregular breathing	10	0	1 (10)
Babinski positive	21	0	1 (5)
Abnormal deep tendon reflexes:			
Increased	5	1 (20)	0
Decreased	14	0	0
Absent	10	0	0
Unspecified	3	0	1 (33)
Subtotal	32	1 (3)	1 (3)
Focal weakness	70	3 (4)	0
Visual dysfunction:			
Anisocoria	16	0	0
Fixed and dilated	11	1 (9)	2 (18)
Anisocoria plus fixed	3	0	0
Subtotal	76	1 (1)	2 (3)
Other visual abnormalities	46	0	0
Miscellaneous sensory abnormality	28	0	2 (7)
Cranial nerve abnormality	29	0	1 (3)
Abnormal named reflex or sign	13	0	0
Other miscellaneous*	205	1 (<1)	3 (1)

* Includes unsteady gait, ataxia, cerebellar signs, etc.

by expanding the total number of patients in the series and thus achieving increasing statistical significance to their data. More recent work by these and other investigators has been prospective [1].

By requiring at least one high-yield feature for ordering skull examinations, the number of skull examinations at University Hospital, University of Washington decreased by 40% during 1975/1976, the first year of the policy, even though only one-half the physicians complied. By 1979, with 5 years experience in the program, use of skull examinations decreased 90% compared with premonitoring rates [10]. DeSmet et al. [1] suggested that different patient populations may warrant different sets of high-yield features. They further pointed out that most efficacy studies aim at diagnosis of skull fracture as the endpoint, stopping short of more significant purpose. Preferably, one should evaluate the ultimate outcome of head trauma—specifically, whether there is injury to the brain.

This study sought to go beyond diagnostic efficacy as an endpoint. I attempted to evaluate the usefulness of skull examinations in modifying management and influencing ultimate outcome of patients with head injuries. Of 1,845 patients with head trauma who had skull film examinations, there were 79 skull fractures, yielding positive findings (diagnostic efficacy) of 1:23. There were 12 depressed and seven basilar fractures. None of the patients with depressed fracture and significant intracranial sequelae required neurosurgical intervention. If all seven patients with basilar fractures were diagnosed by radiography (rather than on clinical grounds) and were begun on antibiotics solely because of radiographic findings, then the skull films affected management and possibly outcome in seven of 1,845 patients (less than 1%). This level of therapeutic efficacy required 264 skull series for every therapeutically significant skull finding. Eleven other basilar fractures were suspected clinically in the emergency room but not demonstrated radiographically. Since no patients had tomography of the skull base, there may have been other basilar fractures that were not diagnosed either clinically or by radiography. The percentage of patients whose management was potentially altered, 0.38%, is very small.

Since this study was retrospective, inferences had to be drawn. A prospective study might show higher therapeutic efficacy. Also, the group of patients with both depressed fractures and significant intracranial sequelae in this study did not require surgical elevation, perhaps an unusual distribution. Future studies might show increased therapeutic and outcome efficacy if patients with clinically unsuspected but radiographically demonstrated depressed fractures required surgical treatment of the fractures.

In evaluating clinical features of head trauma, history and general physical examination showed low predictive value for significant intracranial sequelae with few exceptions, whereas most neurologic abnormalities showed high predictive value (i.e., they were high-yield).These high-yield features, especially loss of consciousness greater than 10 min, serve to point out which patients warrant more elaborate evaluation. Review of table 2 reveals the low expectation of significant intracranial sequelae in patients with loss of consciousness for less than 10 min (less than 1%), headaches (2%), dizziness (2%), intoxication (1%), laceration (2%), etc. (Note that the duration of loss of consciousness was obtained from the emergency room record of "history" and "physical examination." As such, it suffers from the usual inaccuracies of observer recall. However, it represents an attempt to separate brief from prolonged episodes of unconsciousness.)

Traditionally, the main purpose of skull films has been to diagnose (or rule out) simple skull fracture. To that extent, a list of high-yield predictive features for significant intracranial sequelae (table 1) would help eliminate the vast majority of unnecessary films, exposure, and expense. However, Phillips [12] pointed out that occasional false-negative skull examinations can create a false sense of security. He noted cases of increased malpractice jeopardy where negative skull series constituted a liability rather than an asset. the value of the high-yield list in this and other studies lies not in the prevention of a physician from following the dictates of his judgment but in offering guidelines from a large experience that can help mold his judgment in individual instances.

A second purpose of skull films was to detect basilar and depressed fractures, findings that were thought to alter the patient's management by prompting antibiotic prophylaxis or surgical elevation of fragments. In this study, seven basilar fractures were diagnosed by radiography; many already diagnosed on clinical grounds and possibly others demonstrable only by tomography were not visible on skull examinations. Prophylactic antibiotics are the accepted management for all patients with clinically suspected basilar fractures with or without skull film confirmation. If all lacerations and puncture wounds are carefully probed and no depression found, if there is no otorhinorrhea, and if no high yield predictive features for significant intracranial sequelae are present, the implication is that skull examinations are not justified to diagnose basilar or depressed fractures. The next obvious step is to collect a large number of depressed and basilar fractures and determine the high-yield features of this select subgroup. Table 8 could serve as a base to which others might add their experience.

When this study was begun, the expectation was that skull examinations could be minimized by predicting which patients would sustain significant intracranial sequelae and limit radiography to that group. Thus, a high-yield list was identified to establish predictive value of clinical features for the occurrence of significant intracranial sequelae. As this study clearly demonstrated, skull fractures by themselves show poor predictive value for intracranial injury. Similarly, lack of skull fracture does not exclude serious internal injury.

Routine skull examination after head trauma and diagnosis of skull fracture play no appreciable role in the evaluation, management, or outcome of acute brain injury. There is no justification to continue ordering skull examinations for trauma, neither in the adult nor pediatric age group. If there is any clinical suspicion that significant intracranial injury has occurred, then further evaluation should be directed at the brain and intracranial spaces. In many centers, computed tomography (CT) has become the study of choice to evaluate possible intracranial injury after acute trauma.

Zimmerman et al. [13] stated that "computed tomography (CT) represents a major breakthrough in the investigation of head injury. It not only reveals promptly, accurately, and noninvasively the trauma-related abnormalities that were previously demonstrated only by invasive radiology methods, but also shows . . . the time course of various trauma-related processes."

In 218 patients evaluated with both skull examination and CT, 32% had false-negative skull examinations (CT demonstrated significant intracranial hemorrhage in patients with negative skull series). Similarly, 27% had false-positive skull examinations (CT showed no significant intracranial abnormality on patients with fracture by skull x-ray examination). Zimmerman et al. [13] also stated that:

> . . . CT plays a major role by demonstrating the absence of significant parenchymal lesion and by revealing changes due to secondary injury at a time when they are still reversible. . . . CT . . . may obviate . . . more invasive procedures. . . .
>
> . . . CT is the procedure of choice in the initial evaluation of cerebral parenchymal injury. . . . .
>
> . . . skull examinations are performed when the patient's condition is sufficiently stabilized, frequently days after the injury, and then for the evaluation of facial injury, depressed calvarial fracture, or fracture of the cranial base associated with cerebrospinal fluid oto- or rhinorrhea. . . . .
>
> By accurately differentiating the various forms of gross neuropathologic lesions resulting from trauma to the brain, the prognosis can be implied from the CT findings. . . . The results . . . show a significant improvement in mortality rate for intracerebral, subdural, and epidural hematomas. There has been a progressive decrease in the use of arteriography, skull radiography, and in surgical intervention.

Barry and Rothman [14] noted that "patients with acute or chronic histories of head trauma are now diagnosed with CT. . . . In the last six months there has not been a single case of a false negative report in a patient with a significant cranial hematoma" at Yale–New Haven Hospital.

According to Samii et al. [15], "experience has demonstrated that CT is superior to any other technique in the diagnosis of acute head injuries and in the follow-up as well." Isamat et al. [16] found that "the use of CT scan [high-dose steroids and intracranial pressure monitoring] . . . [has] spectacularly changed the outcome of these patients" with head injuries.

After acute head injury, the desirable sequence of evaluation is as follows: First, there is a thorough clinical evaluation to include history and general physical and careful neurologic examination. Then, lacerations or puncture wounds should be probed for depression. Observation should follow, either by reliable family members at home or, if warranted, in the hospital by appropriate staff. If any of the high-yield features for predicting significant intracranial sequelae (table 1) are present, further neurodiagnostic evaluation is generally indicated. (Occasionally a patient with acute head trauma may have a high-yield feature representing old abnormality, such as hemiplegia due to old stroke, and may not warrant further evaluation.) CT should be considered the primary, noninvasive, diagnostic procedure of choice to evaluate intracranial sequelae of trauma. When CT is unavailable, the primary care physician in consultation with the neurologist or neurosurgeon may choose among radionuclide scan, cerebral arteriogram, or direct surgical intervention. Skull radiography may be valuable as an adjunct to help clarify equivocal CT findings in some cases and to evaluate palpable depression or clinically apparent basilar fracture.

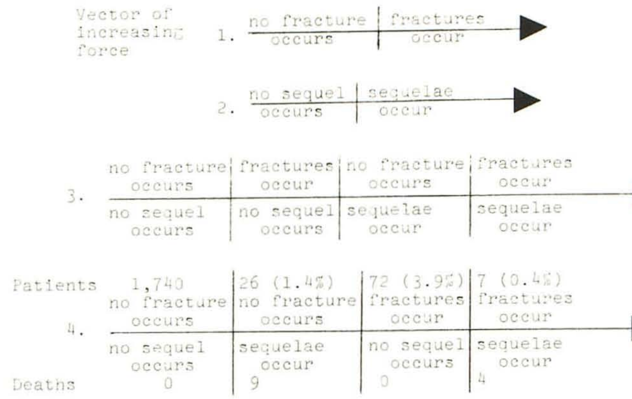

Fig. 1.—Arrows represent vectors of increasing force. *Vector 1*: fractures will occur. *Vector 2*: significant intracranial sequelae will occur according to force. *Vector 3*, combining fractures and intracranial sequelae, is illogical with regard to fracture component and is discarded in favor of vector 4. *Vector 4* shows that when forcefulness is limited, significant intracranial sequelae occur without fracture. More force causes fracture without intracranial sequelae. When the degree of trauma becomes very severe, fractures and significant intracranial sequelae result.

The data in this study suggest an interesting possibility. Clearly, the presence of skull fracture places the patient at a higher risk of intracranial hemorrhage and death than the absence of skull fracture. However, there were 72 patients in this study who sustained skull fracture but had no significant intracranial sequelae. For this group, the skull fracture may have protected the brain and meninges by dissipating the force of the trauma. This possibility is demonstrated by the diagram in figure 1. When forcefulness is limited, significant intracranial sequelae occur without fracture. More force causes fracture without intracranial sequelae. Ultimately, as the degree of trauma becomes very severe, fractures and significant sequelae result.

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