Skull roentgenography for patients with head trauma: the use of high-yield criteria

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Head injury is the presenting complaint in an estimated 60 000 emergency department visits each year in Ontario alone.[1] In most cases a radiologic examination is done because of the traditional belief that no examination of a patient with a head injury, however trivial the injury may be, is complete without skull roentgenography.[2-4] This belief has been questioned by a number of investigators,[5-8] who have attempted to identify a more "cost-effective" rationale for the use of skull roentgenography and thus avoid the indiscriminate use of this procedure. The chief reasons cited for their studies were the low yield of fractures, the unnecessary expense and the uncertainty that the finding of a skull fracture would alter management in most cases.

Much of the data leading to opinions expressed for or against high-yield criteria for skull roentgenography have been based upon the retrospective review or "chart audit" type of analysis.[8-10] This kind of study is notoriously unreliable, for it depends upon completeness of records and upon assessment of charts for details they may not have originally contained.[11]

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The study described in this paper began with a retrospective evaluation of proposed high-yield criteria to gain an impression of their validity. Once their validity had been confirmed a prospective study of their application was undertaken to further clarify the place of high-yield criteria as an adjunct to sound clinical assessment of the patient with a head injury.

Methods

In Kingston, Ont. the emergency departments of the two general hospitals affiliated with Queen's University (Kingston General and Hotel Dieu) have full-time attending staff and house staff coverage. There are approximately 85 000 visits to these departments each year. Skull roentgenograms are obtained in posteroanterior, stereo lateral and two Towne's projections.

It was decided to use high-yield criteria other than those of Phillips,[6] and these were tested initially by reviewing the charts of the 1366 patients with head injuries seen from Dec. 1, 1977 to Nov. 30, 1978. One proposed criterion (retrograde amnesia) was eliminated because it was considered too subjective. The five criteria left to be used in the prospective study are shown in Table I, which illustrates the data form used. Note that criterion 2 is decreased level of consciousness *when examined*; a history of loss of consciousness after a head injury in an asymptomatic patient would not qualify as a high-yield criterion.

In the prospective study the examining physician completed the

Table I—Representation of data form employed in a study of the use of skull roentgenography for patients with head injuries in Kingston, Ont.

Patient's name_____
Address_____
Age_____

Criteria	Indicate if present
1. Vomiting twice or more if age greater than 20 years	_____
2. Decreased level of consciousness when examined	_____
3. Cerebrospinal fluid rhinorrhea or otorrhea, or hemotympanum	_____
4. Palpable bony abnormality or depression	_____
5. Unexplained neurologic abnormality	_____
6. Other (explain)	_____
	_____

Physician's signature _____ Date_____ 19__

data form at the time of requesting skull roentgenography; if none of criteria 1 to 5 was present an explanation for the request had to be entered as criterion 6. Over a 5-month period, Nov. 1, 1979 to Mar. 31, 1980, 153 patients consecutively undergoing skull roentgenography because of head trauma were divided into two groups: those with at least one high-yield criterion and those with none.

At Kingston General Hospital computer-assisted tomography of the head can be performed within 5 to 10 minutes of the patient's arrival in the emergency department. Consequently, some of the patients with the most severe head injuries were not included in the study since, after initial assessment, resuscitation and stabilization, computer-assisted tomography would have been done immediately as the investigation of choice (and time not have been spent on skull roentgenography).

Table II—Comparison of rates of skull roentgenography in patients with head trauma

Year and place of study	No. of skull roentgenograms per 1000 patient visits to emergency departments
1976–77 Harborview Medical Center, Seattle[6]	10.3
1976–77 University Hospital, Seattle[6]	1.2
1976–77 Portsmouth, Virginia[10]	1.0
1977–78 Kingston (retrospective study)	0.88
1979–80 Kingston (prospective study)	0.46

Table III—Distribution of skull fractures detected by roentgenography among 153 patients in the prospective study in Kingston

High-yield criteria	Skull fracture; no. of patients: Present	Absent
Present (n = 78)	15	63
Absent (n = 75)	1	74
Total	16	137

Table IV—Frequency of each high-yield criterion

Criterion	Skull fracture; no. of patients: Present	Absent
Vomiting twice or more if age greater than 20 years		3
Decreased level of consciousness when examined	10	39
Cerebrospinal fluid rhinorrhea or otorrhea, or hemotympanum	3	6
Palpable bony abnormality or depression	5	14
Unexplained neurologic abnormality	4	10
Total	22	72

Results

The retrospective review revealed that of the 1366 patients seen with head injuries over a 1-year period 746 underwent skull roentgenography and 40 had skull fractures. Had the presence of one or more high-yield criteria been the sole indication for skull roentgenography during that period, only 203 patients (73% fewer) would have undergone the procedure and 34 fractures would have been found.

Undertaking the prospective study virtually halved the rate of skull roentgenography in patients with head trauma, presumably by causing physicians to "think twice" before ordering this procedure for a patient without any of the high-yield criteria (Table II). The comparison of the rates in Kingston, Seattle[6] and Virginia[10] is interesting, but the differences are hardly likely to be significant owing to population differences.

All but 1 of the 16 skull fractures seen during the prospective study period were in the patients with high-yield criteria (Table III); the difference between the proportions with skull fractures in the two groups was highly significant ($P < 0.001$).

From the frequency with which each criterion was identified in patients with and without skull fractures (Table IV) sensitivity and specificity ratings as well as predictive values were determined (Table V). The predictive values of the presence and absence of each criterion (i.e., the likelihood that their presence or absence would correctly predict the presence or absence of a skull fracture) are best illustrated in the bottom row of Table V; here we can see that the predictive value of the absence of all the criteria is 0.987 — that is, if no high-yield criterion was identified in any given patient the chances were 98.7% against that patient's having a skull fracture. As expected, decreased level of consciousness when examined was the most sensitive criterion, although the least specific, and vomiting twice or more if age greater than 20 years was unhelpful, although the retrospective study had suggested it might be valuable. The relatively low specificity of cerebrospinal fluid rhinorrhea or otorrhea, or hemotympanum, all of

Table V—Sensitivity, specificity and predictive value of each criterion

Criterion	Rating (%): Sensitivity	Specificity	Predictive value: Presence of criterion	Absence of criterion
Vomiting twice or more if age greater than 20 years				
Decreased level of consciousness when examined	0.666	0.262	0.204	0.827
Cerebrospinal fluid rhinorrhea or otorrhea, or hemotympanum	0.200	0.904	0.333	0.826
Palpable bony abnormality or depression	0.333	0.777	0.263	0.830
Unexplained neurologic abnormality	0.266	0.841	0.285	0.828
Combined	0.937	0.540	0.192	0.987

which are pathognomonic of basal skull fracture, indicates how inadequate skull roentgenography is in detecting such fractures.

Although the numbers in this study were small, the presence of more than one high-yield criterion in any particular patient greatly increased the likelihood that the patient had a skull fracture (Table VI).

Among the indications for skull roentgenography in the patients without high-yield criteria, soft tissue injury accounted for just over one half and nonspecific symptoms or signs for another third (Table VII).

Discussion

The one fracture that occurred in the group of patients without high-yield criteria was in a 3½-month-old girl who rolled off a kitchen table and struck her head on the corner of a chair. The infant was seen by her family physician, who found her to be bright, active and entirely asymptomatic. Nevertheless, skull roentgenography was done and a linear fracture in the parietal area of the skull was found. Since the infant was so well clinically, she was discharged home, with instructions to her parents to watch her closely. She suffered no sequelae.

Other studies have found that some linear skull fractures in children may be missed if high-yield criteria are rigidly adhered to;[5,10,12] it is an important premise that failure to detect all linear skull fractures in children will in no way jeopardize the children. Harwood-Nash and colleagues[13] examined 4465 children with head injuries and found that 6% of those without a skull fracture and 3% of those with a skull fracture had subdural hematomas. Even with birth injuries excluded, 75% of the subdural hematomas occurred in children without a skull fracture. They concluded that "the presence of a skull fracture alone without associated abnormalities of the sensorium or central nervous system is of little significance, and does not necessitate automatic admission to hospital", and that "it is not the presence of a skull fracture that is the important consideration, but rather the effects and sequelae of trauma to the skull contents".

One recent article from California estimated that 70% of skull roentgenography was done for "medicolegal" reasons,[14] although the proportion of such examinations in Kingston was only 7%. One of the values of using high-yield criteria should be the elimination of medicolegal roentgenography. Once objective data can be produced to show that it is reasonable medical practice *not* to perform skull roentgenography in asymptomatic patients with head trauma, no legal reasons will exist, despite the emotional response to the potential for missing a skull fracture.

In Kingston the neurosurgical services do not routinely admit asymptomatic patients with skull fractures but send them home if the usual requirements for adequate supervision of those with minor head injuries can be met. In other centres any patient with a head injury and momentary loss of consciousness will be automatically admitted "for observation". It would be of no help to emergency physicians (especially in areas with cutbacks in numbers of hospital beds) if a more uniform approach to the patient with a minor head injury could be defined.

There can be little doubt that high-yield criteria do what they were intended to do; that is, identify patients likely or unlikely to have a skull fracture. The controversy occurs (along with a host of anecdotes) when the case for their use is overstated to the extent of forbidding physicians to perform skull roentgenography on a patient when all the high-yield criteria are absent. These criteria do have a place in the assessment of patients with minor head trauma, but that place is to guide physicians through statistical probability, not to dictate to them or overrule their judgement and experience.

The reduction in amount of skull roentgenography performed if high-yield criteria were adhered to would be about 75%, according to the results of this study, and the potential cost saving for Canada, extrapolating from the Kingston data, would be around $3½ million. One can hardly guess what the saving might be if indiscriminate roentgenography of other parts of the body was questioned.

It is well accepted that 5% to 10% of unconscious patients with a head injury have an associated cervical spine injury. This potentially devastating injury should be sought clinically and with cervical spine roentgenography — the most urgent radiologic examination for the patient with a serious head injury.[15]

Table VI—Chance of there being a skull fracture if more than one criterion was present

	No. of criteria		
Variable	1	2	3
Patients, no.	64	12	2
Fractures, no.	9	5	1
Chance, %	14.1	41.7	50

Table VII—Reasons cited for ordering skull roentgenography when high-yield criteria were absent

Reason	No. (and %) of cases
Soft tissue injury (laceration, bruise, abrasion etc.)	39 (52)
Headache	15 (20)
Pallor, nausea, "grogginess"	11 (15)
Medicolegal	5 (7)
Parental request	4 (5)
Other	6 (8)

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A complication of catheterization of the left internal jugular vein

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Malpositioning of central venous catheters is known to occur in up to 38% of cases in which the catheter is introduced through an antecubital vein.[1,2] When the catheter is introduced through an internal jugular vein this problem is less frequently appreciated. We report here two cases of aberrantly positioned central venous catheters introduced through the left internal jugular vein.

Case reports

The first patient, a 20-year-old woman, was transferred to our hospital with a diagnosis of gonococcal endocarditis and worsening heart failure secondary to mitral regurgitation. The heart failure responded well to treatment with diuretics. Initially she was given cephalothin sodium intravenously, but later cefoxitin sodium was substituted. A central venous catheter was required for long-term administration of antibiotics.

The second patient, a 76-year-old woman, was admitted to hospital because of a syncopal episode. She was found to have sick sinus syndrome with profound bradycardia. A temporary pacemaker was inserted through the right internal jugular vein, and subsequently a permanent one was inserted through the left cephalic vein. A routine 2-day course of cephalothin sodium given intravenously was begun following implantation of the permanent pacemaker, but owing to a lack of suitable peripheral veins a central venous catheter was required.

In both cases a 16-gauge, 20-cm-long catheter, the Deseret Intracath (Deseret Pharmaceutical Co., Sandy, Utah), was introduced percutaneously into the left internal jugular vein. The catheter advanced easily, and when it was in its final position blood was readily aspirated. No discomfort was noted by either patient during the procedure or immediately thereafter. Several minutes following the start of an infusion of cephalothin sodium both patients complained of severe left shoulder and left pleuritic pain; the pain subsided soon after the infusion was stopped.

Chest roentgenograms made shortly thereafter revealed aberrant positioning of the central venous catheters; the positions were similar in the two patients (Fig. 1). No pneumothorax was noted in either patient. An injection of Renografin-76 (meglumine and sodium diatrizoate) through one catheter confirmed its location in the left internal thoracic (internal mammary) vein (Fig. 2). In the first case the catheter was withdrawn slightly

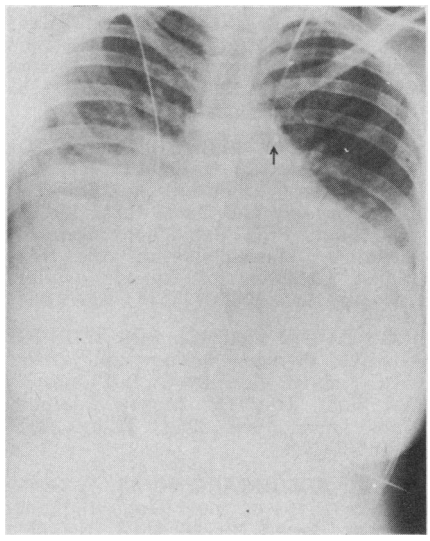

FIG. 1—Central venous catheter positioned aberrantly in left internal thoracic vein; arrow indicates tip of catheter.

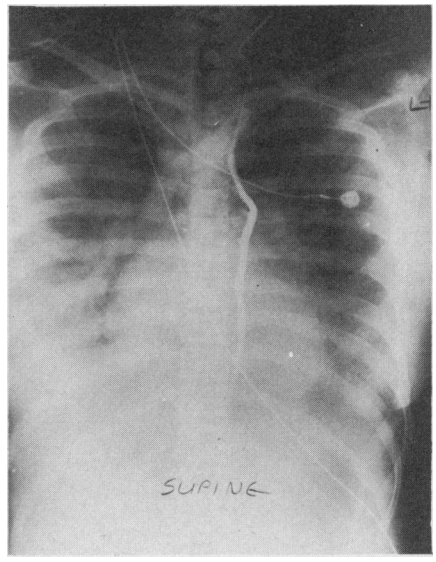

FIG. 2—Injection of Renografin-76 (meglumine and sodium diatrizoate) confirms catheter's position.

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