4
Skull X-Ray

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UTILIZATION, COSTS, AND CONTROVERSIES

In 1970, approximately 4.2 million radiographic skull examinations were performed, representing 3 percent of the total number of X-ray examinations in the United States in that year. Over 86 percent of these procedures were performed in hospitals (27). The average number of films used per examination was four, and in 1970, the median gonadal dose per exam for both sexes was less than 0.5 millirad. The bone marrow dose was in the medium range, at 78 millirads per exam.

Skull X-rays are ordered to detect and evaluate abnormalities of the head. They provide strong evidence of skull fracture and in some cases provide clues about abnormal intracranial conditions. They have held a traditional place in the evaluation of patients with head injury or sudden onset of unconsciousness or coma.

Physicians' claims for skull X-rays performed on California medicaid patients in 1978 are shown in table 8. The limited skull examination plays a minor role in radiologic practice in California. Over 85 percent of skull examinations were comprehensive. Comparing this table with claims by physicians shown in table 9 reveals that radiologists perform most hospital skull X-ray procedures but only 38 percent of such examinations performed in physicians' c) f-fices.

In the past decade, the skull X-ray has been criticized as an overused and not very valuable radiological procedure (1,66,85,107). This criticism has stemmed from studies demonstratin$_g$ the low yield of positive skull X-rays (9) and low sensitivity of the skull X-ray in detecting clinically important intracranial abnormalities such as subdural hema torna (114) and cortical a trophy (119); from the general unimportance of detecting a fracture in the absence of any clinical evidence of intracranial damage (58,64); and from the arrival of a noninvasive diagnostic imaging technology that offers vastly superior in-

Table 8.— Medicaid Skull X-Ray Claims in California Submitted by Physicians in First Quarter of 1978, by Location of Service

	Inpatient[a]	Out patienta	Office	Other	Total
70250 Skull: limited. .,	353–(2 1.7 %)	403 (10.8°f0)	893 (14.6%)	55 (07.7%)	1,704 (14.0%)
70260 Skull: complete 1.274	(78.3°/0)	3,319 (19.2%)	5,219 (85.4%)	657 (92.3%)	10,469 (86.0°0)
Total. .	1,627	3722	6,112	71 2	12,173

[a]Recorded only when hospital and physicianbill separately for the service (splitbilling arrangement)

SOURCE Urban Institute sample of 5000 solo practitioners, including 177 radiologists

Table 9.—Medicaid Skull X-Ray Claims in California Submitted by Radiologists in First Quarter of 1978, by Location of Service

	Inpatient[a]	Out patienta	Office	Other	Tot al
7 0 2 5 0 Skull. limited	323(21.3%)	400 (1 2,40/')	195 (08.4%)	409 (84.3%)	927 (12 30.)
70260 Skull: complete, .,	1,192 (78.7%)	2,836 (87.6%)	2,125 (91.6°6)	*76 (15. 7%)*	*6,629 (87.7%)*
Total ., . . ., . ., .,	1,515	**3,236**	**2,320**	**485**	**7,556**

[a]Recorded only when hospital and physici an billseparatelyfor the service(spli bil lingarrangement)

SOURCE Urban Institute sample of 177 soloradiologists(32 6 percent of al l solo radiologistsi n California)

formation on intracranial disease and injury, namely, the computed tomographic (CT) scanner (68,126).

Although there are no national data showing the extent to which the use of the skull X-ray has been affected by these factors, anecdotal evidence from a few institutions with CT scanners indicates that many patients, particularly head trauma victims who would have been given skull radiographic examinations, are examined by CT instead. In one hospital, it was reported that 24 percent of patients suffering from acute head injury were spared a skull roentgenogram after the introduction of CT (126). Even without CT scanning, policies regarding skull X-rays in two emergency rooms reduced the rate of use of the procedure by **29** percent (99,100).

SKULL X-RAY EVALUATION

The evaluation literature has had an important place in framing the debate about the appropriateness of the skull X-ray. Two kinds of studies have provided evidence about the usefulness of this procedure: 1) studies of diagnostic efficiency, and 2) studies of high-yield criteria for ordering skull examinations in emergency rooms.

Diagnostic Efficiency of Skull X-Ray Examinations

The diagnostic efficiency of a radiologic test can only be assessed in terms of the diagnoses of interest. If one is concerned with the diagnostic efficiency of the skull X-ray in detecting skull fractures, then the skull X-ray is generally the definitive test. Except for examination during an operation or postmortem, there is generally no other method for determining whether a skull fracture exists. Thus, for skull fractures, the observed true-positive rate of the skull X-ray approaches 100 percent. Specificity (true-negative rate) is also presumably high.

The diagnostic efficiency of the skull examination becomes more questionable when one considers other, more clinically significant, diagnoses. Except for depressed fractures, which sometimes require surgery, the mere presence of a fracture is unlikely to influence therapy in head injury patients. The more important question is how well a test can detect intracranial abnormalities. Here, the skull X-ray does not perform well.

In a 1971 study of 100 patients with acute subdural hematoma, Talalla and Morin reported the findings of skull X-rays taken in **50 of these** cases (114). * While **60** percent of the skull X-rays were abnormal, in only 5 percent of the examinations was a subdural hematoma identified. The rest showed fractures or other abnormalities unspecific to the diagnosis. A similar study of subdural hematomas of traumatic origin in England showed that for those cases where a skull X-ray was performed, the positive rate was 48 percent for simple hematomas and 80 percent for complicated hematomas (64).

These pre-CT studies cast doubt on the ability of the skull X-ray to differentiate between patients with and without serious injury. A later study comparing the skull X-ray examination with CT scanning in patients with head trauma draws an even sharper picture of the limitations of the skull examination.

The results of skull examinations taken in **76** percent of 285 consecutive acute head trauma patients who received CT examinations were recorded by Zimmerman and his colleagues (126). Of those patients with CT evidence of significant intracranial abnormality, skull films were normal in 31 percent of children and 33 percent of the adults. Of those patients with negative CT

* Skull X-rays were not taken in urgent situations, or when the patient did not survive long enough, Thus, the efficiency of skull X-ray is probably underestimated for the population as a whole. However, since the procedure is only feasible for the subset of patients who did receive it, this group should be considered representative of the relevant population,

scans, 23 percent of the adults and 32 percent of the children showed fractures on the skull film. * If intracranial damage is considered, it appears that approximately one-third of abnormal skull examinations are unrelated to the diagnosis of interest. In detecting significant intracranial damage, CT scanning is the definitive procedure in the same sense that the skull X-ray is for fracture.

Even lower estimates of skull X-ray sensitivity were obtained in studies of patients with nonacute problems suggestive of intracranial disease. A study of patients admitted to a psychiatric hospital with symptoms suggestive of organic brain disease showed that the skull X-ray was abnormal in only **6** percent of cases found to be abnormal by CT scanning (119). A comparative study of skull radiographs, CT scans, and radionuclide bone scans in detecting cancerous metastasis to the skull (calvaria) showed that the skull X-ray detected only 55 percent of the calvarial metastasis identified by one or more of the three procedures (68). The skull X-ray was uniqueIy responsible for the detection of 1 of the 32 total calvarial lesions.

Were it not for the difference in the cost of the skull X-ray and CT head scans, the evidence comparing the diagnostic efficiency of skull X-ray and CT scanning in identifying intracranial abnormalities would argue for virtual replacement of skull films by CT scans in the conditions studied. However, the technical cost of a skull examination was estimated at about 1] percent of that of a CT examination in **1977 (48). Consequently, the appropriate** place of these two examinations in the applications discussed is not so straightforward. At the very least, it may be argued that head injury patients who received CT examinations should not **also** receive skull X-rays as a routine procedure.

High-Yield Criteria for Skull X-Rays

Historically, skull X-ray examinations have been used as a standard radiological procedure in the evaluation of patients with head injur$_y$. Over time, the procedure has come to be viewed as necessary to the provision of quality care, and it has been claimed that many such examinations are ordered by emergency room physicians for medico-legal reasons or because the patient or patient's family request it, and not because the physician sees the examination as contributin$_g$ greatly to his or her information **(1,66).** The yield of abnormal findings in skull X-rays ordered in this way is low. Studies of diagnostic yield in hospital emergency rooms in this country and in Britain have reported rates rangin$_g$ from under 2 percent to about 8.5 percent (9, 32,36). It is not surprising, then, that the search for criteria for ordering skull X-ray procedures to improve diagnostic yield would have begun with the emergency skull X-ray.

The first attempt to determine which presenting signs, symptoms, or risk factors would be good predictors of an abnormal skull X-ray finding was reported by Bell and Loop, who identified 21 objective and subjective findings present in at least 10 percent of positive skull X-ray examinations obtained in 1,500 consecutive skull examinations in two hospital emergency rooms (9). These 21 attributes, termed "high-yield findings, " included such elements as presence of unconsciousness for more than 5 minutes (present in 41 percent of all skull fractures found by radiograph); discharge from the ear (present in 30 percent); accident at work or gunshot wound (present in 15 percent); and serious suspicion of **a** fracture (present in 76 percent).

Only one patient with a positive skull fracture did not have at least one of the high-yield findings, and the radiograph made no difference to the management of the patient's care. Had skull X-ray examinations been limited only to those patients with the high-yield findings, however, approximately 29 percent of the 1,500 **patients would not have had the examination.**

The performance of the 21 high-yield findings was recently studied in a sample of 594 cases of head trauma in a military hospital's *emergency* room (32). Of the 17 skull fractures detected, 7 had none of the high-yield findings. All 7 were children under 17 years of age. The patient sam-

*Because the patient populations included only those for whom a CT scan was ordered, patients who are bound to be sicker than most, results probably overestimated the sensitivity of the skull X-ray and underestimated its specificity, although the magnitude of the effect is not known.

ple in this study was 55 percent children, compared to 9.7 percent in the Bell and Loop study (9), indicating that in children there may be a different relationship between symptoms and X-ray results. With one exception, none of the high-yield findings was significantly correlated with positive skull radiographs (p **0.10),** but the authors did not report on the number of radiographs that would have been saved had the criteria been applied to the patients in the study.

A recent British study of 504 head injury patients found that six of the nine skull fractures contained one or more of just seven findings: headache/concussion, vomiting, loss of conscious, focal or general signs of central nervous system involvement, scalp hematoma, scalp laceration, and ear bleeding (36). These findings were selected arbitrarily by the authors, and their performance in terms of saved radiographs was not assessed.

The fundamental weakness of studies of high-yield criteria for skull X-rays stems from their emphasis on diagnostic yield in the face of overwhelming evidence that X-ray findings in patients with head injury mean very little to patient management. Detection of a fracture is useful only to the extent that it indicates potential cerebral damage. Those with serious intracranial injury often have no fracture, while those with fracture and no other clinical findings frequently require no management save observation (36, 58). In some areas, hospital admission for observation is automatically prompted by a positive skull X-ray **(36), thus** raising the costs issuing from the use of this procedure on all head injury patients.

One must question the use of a method such as high-yield criteria to reduce the number of examinations of a procedure that offers little information relevant to therapy when the more appropriate strategy may be to eliminate skull X-rays altogether in favor of CT scanning, which directly detects the important conditions. Because CT scans are expensive, however, identification of high-yield criteria for ordering CT scans on head injury patients is of utmost urgency. One such study has been performed to date **(57).**