THE NATURAL HISTORY OF NONSURGICALLY TREATED SUBDURAL HEMATOMA AS STUDIED BY RAPID-SEQUENCE SCINTIPHOTOGRAPHY

John Lusins and Jay H. Katz*

Mount Sinai Hospital and School of Medicine, New York, New York

Rapid-sequence scintiphotography has been employed to follow the evolution of chronic and subacute subdural hematoma in six patients and was correlated with patient improvement, conventional radiologic angiography, and the static scan. The reliability of the scintiphotogram is greatly improved when the scintillation camera is interfaced with a digital computer capable of producing smoothed images, frame summation, and relative flow curves from selected regions of interest.

Operative removal has been, and in most institutions still is, the method for treatment of symptomatic subdural hematoma. However, there has recently been a growing interest in the nonsurgical management of this lesion (*1–6*), an approach that was pioneered by Bender (*1*) who has successfully treated over 100 cases in this manner (*7*).

The nonsurgical treatment consists of high dosage of a corticosteroid combined with bed rest. There is close monitoring of the level of consciousness and vital signs as well as frequent re-evaluation of the patient's neurologic status. Some groups have also routinely used intravenous mannitol as well as corticosteroids (*4*).

The patients selected for the nonsurgical treatment of subdurals are closely evaluated and only those who have a relatively good level of consciousness are included. Comatose patients are never managed in this manner. Similarly, if a patient who is selected for nonsurgical treatment shows signs of deterioration, he is immediately transferred to the surgical service.

When the clinical diagnosis of subdural hematoma is suspected, it is generally verified by means of conventional (radiography) cerebral angiography, a technique that is also employed to document its gradual resolution in patients who have not had surgery (*1–7*). Static brain scans with a variety of radiopharmaceuticals have also been widely used to aid in the diagnosis (*8–18*). Sporadic reports have also appeared in the literature on the value of rapid-sequence scintiphotography in this condition.

Our access to nonsurgically treated patients at this institution has permitted us not only to document the reliability of the scintiphotographic method in the initial diagnosis of subdural hematoma but also has allowed us to use this method as a means of following the natural history of this lesion. The present report deals with six patients who were followed with sequential studies over the course of a 4–6 month interval.

PATIENT SELECTION AND METHODS

All patients had angiographically demonstrable subdural hematoma and distinctive neurologic symptoms, the onset of which could be dated to within weeks of their admission to the hospital (Table 1). The initial scintiphotography was performed within 24 hr of the radiographic study. In two patients, a routine scintiphotographic study provided the first clue to the diagnosis and conventional angiography was done subsequently.

The scintiphotographs were performed with a gamma camera (Dyna Camera II, Picker Corp.). An anterior view was obtained after 10–12 mCi of ^{99m}Tc pertechnetate contained in a volume of less than 1.5 ml was injected rapidly through the median or basilic vein. The data were stored both on videotape and a disk of a "Gamma 11" computer system (Digital Equipment Corp., Maynard, Mass.). The digitized information was collected in a 64 × 64 matrix at the rate of two frames per second for 30 sec. At a later time the stored information could be

Received April 3, 1974; revision accepted June 24, 1974.

For reprints contact: John Lusins, Dept. of Neurology, The Mount Sinai Hospital, 100th St. and Fifth Ave., New York, N.Y. 10029.

* Present address: Dept. of Nuclear Medicine, Albany Medical College, Albany, New York.

TABLE 1. SUMMARY OF CLINICAL PRESENTATION AND COURSE OF ILLNESS

Age–sex	Type of trauma	Clinical symptoms	Clinical course
57–M	Hit head against door frame of truck 2 weeks prior to admission (lt subdural)	Moderate aphasia, rt hemiparesis	Pt returned to normal by 4 weeks, aphasia clearing first
48–M	Fell in bathtub 1 week prior to admission (lt subdural)	Lethargic, right hemiparesis	Lethargy improved by 72 hr. Pt hemiplegia returned to normal by 3 weeks
51–M	Pt spontaneously developed a rt subdural 2 weeks after ligation of an aneurysm	Mild lethargy, moderate organic mental syndrome	Lethargy improved 48 hr, organic mental syndrome gradually improved over 4 weeks
62–M	Fell on ice 3 weeks prior to admission (rt subdural)	Agitated, mild organic mental syndrome. Mild lt hemiparesis	Pt returned to normal by 3 weeks
72–M	Fell at home 3–4 weeks prior to admission (rt subdural)	Marked organic mental syndrome, but good level of consciousness	Mild organic mental syndrome still present at 6 weeks, but cleared at 3 months
71–F	Trauma to head during fall in street 2 weeks prior to admission (lt subdural)	Mild lethargy, rt hemiparesis	Lethargy cleared by 72 hr, hemiplegia returned to normal by 5 weeks

displayed on a Tektronix 611 oscilloscope on a frame-by-frame basis. The software provided by the manufacturer also permitted smoothing and summation of selected sequential frames to allow for greater statistical reliability and improved visual resolution of the images.

In order to compare the relative rates of perfusion in the periphery of the two cerebral hemispheres on a more quantitative basis, "regions of interest" were delineated in the following manner. A smoothed composite image was obtained by summating over the entire 60 frames. This included both the arterial and venous phases. Using the cursor, a rectangular area was outlined over the upper half of the normal hemisphere in such a manner as to place the lower lateral corner at the outermost margin of activity. The medial margin of the rectangle was arranged so as to exclude the sagittal sinus. A region of interest was then placed at a corresponding location in the contralateral cerebral hemisphere using a program which automatically created a symmetrical rectangle of equal area when a single corner was defined by the cursor (Figs. 1 and 2). The activity in each region of interest could then be plotted as a function of time (frame number) and the curves superimposed. Peak activity was reached 3–4 sec after its initial appearance and in the different studies varied from 350–500 counts/0.5 sec in the "normal" region of interest. These variations were due to differences in the site of the area selected, differ-

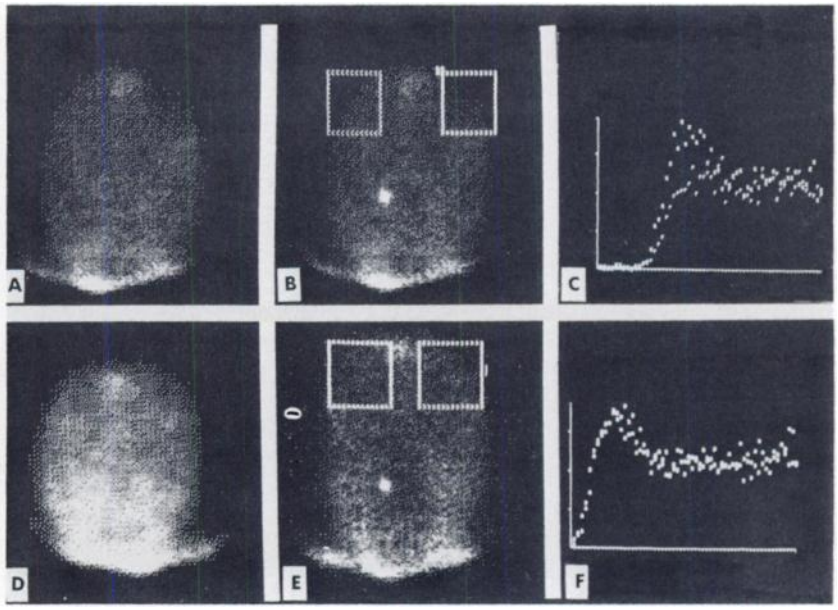

FIG. 1. Fifty-seven-year-old man developed right hemiparesis after head injury. Cerebral angiography demonstrated left-sided subdural hematoma. (A) Summated smoothed image obtained from multiple sequential frames shows concave-shaped peripheral defect on left in area of subdural. (B) Symmetric areas of interest are outlined over both cerebral hemispheres using a movable cursor. (C) Time–activity curve plotted from two areas of interest in (B). Activity from area without subdural is 2 s.d. higher than activity from area of subdural. (D) Summated, smoothed symmetric flow study of same patient was obtained at 12 weeks. Concave defect seen in (A) is no longer present. (E) Symmetric areas of interest were again placed over two cerebral hemispheres. (F) Time–activity curves obtained from both areas of interest no longer show significant difference in activity.

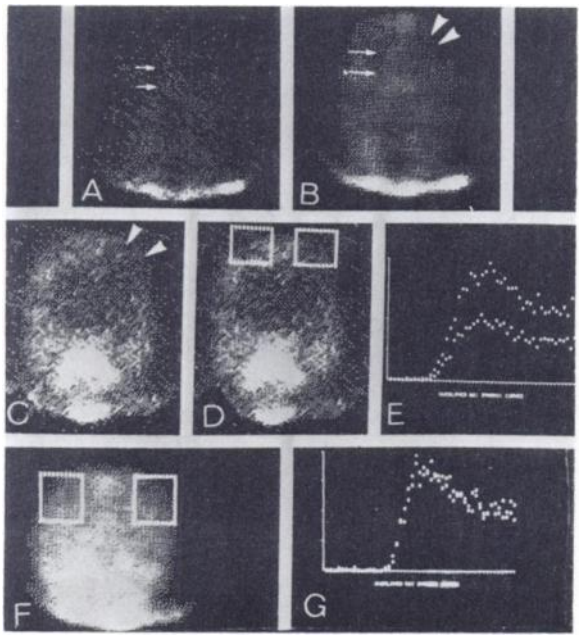

FIG. 2. Man (48 years old) with history of head trauma. Technetium-99m-pertechnetate rapid-sequence scintiphotogram was performed 1 week after injury. (A) Early arterial phase shows left-to-right deviation on anterior cerebral artery. (B) Image obtained from multiple sequential summated frames. Concave peripheral defect is noted on left (large arrows) in area of subdural hematoma. (C) Image of summated multiple sequential frames without smoothing still shows defect on left in area of subdural (arrows). However, subdural is not as well outlined as in (B). (D) Symmetrical areas of interest are outlined over two cerebral hemispheres using a movable cursor. (E) Time–activity curves were obtained from two areas of interest showing activity from area without subdural being 2 s.d. more than from area with subdural. (F) Repeat rapid-sequence scintiphotogram from same patient at 11 weeks. Image obtained from summated, smoothed multiple frames fails to show concave defect seen in (A). Symmetric areas of interest are outlined over cerebral hemispheres. (G) Time–activity curves from areas of interest in (F) fail to show any difference in activity on two sides.

ences in cardiac output, etc. However, in any given study, the relative activity in the two sides of the brain could be reliably compared and were considered to be proportional to blood flow. Significant differences between the two sides were deemed to be present when both the activity at the peak and the area beneath the time–activity curves differed by more than 2 s.d. (In calculating the area, the down slope of the initial pulse was extrapolated exponentially to 1% of the peak level.) Four view static scans were obtained 1–2 hr postinjection.

The patients were re-evaluated with the same techniques at intervals of 4–6 weeks, a total of three studies being obtained over a period of 3–4 months.

RESULTS

Initial study. In all subjects a definite, albeit poorly delineated, area of diminished activity in the periphery of the affected hemisphere could be appreciated in single (0.5 sec) frames obtained during both the early and late phases of perfusion. Since the information contained in such frames was limited to about 2,000 data points, considerable improvement in visualization was obtained when three or four frames were summated. In such summated images, a distinct segmental or crescent-shaped area of reduced activity extended from the convexity of the brain to a variable depth in the direction of the sagittal sinus (Figs. 1 and 2). The extent of the perfusion defect could be roughly correlated with the shift of the vessels seen in the conventional angiogram (Fig. 3). The time–activity curves obtained from the regions of interest indicated significant differences in flow between the two sides both in terms of integrated and peak activities. In five of six patients the classic "crescent sign" was present in the static scan on the side which had been relatively avascular using the flow study. In one patient the initial static scan as well as the two subsequent studies were normal.

Second study. At the time of the second study all patients had shown substantial clinical improvement. Four were considered to be entirely normal from the neurologic standpoint but two still had mild organic–mental signs. Repeat rapid-sequence scintiphotographs revealed that the distinct perfusion defects which had previously been apparent by simple visual analysis could no longer be discerned with any degree of certainty. However, the time–activity curves obtained from symmetrical areas of interest placed as closely as possible to those of the original study demonstrated that there was still diminished flow in the area of the hematoma. The differences in the curves were not as marked as in the acute phase and indeed in two subjects were only of borderline significance. This suggested that the hematoma had diminished in size but was still present in all. Indeed, the conventional angiogram in one of

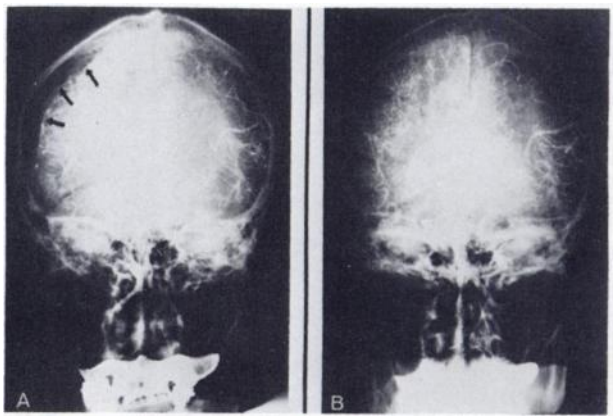

FIG. 3. Angiogram of one of patients in the study. (A) Large subdural on right side as outlined by arrows. (B) Repeat angiogram at 12 weeks showed that previously noted subdural has almost completely resolved.

the patients with residual symptoms also demonstrated the persistence of a hematoma that was, however, considerably smaller than it had been 1 month previously. Experience with over 100 medically treated patients with subdural hematoma has also demonstrated the gradual decrease in size of the lesions which often do not resolve completely for 3–4 months (*7*). Static brain scans also remained positive in the five patients mentioned earlier.

Final study. Five of the six patients were available for study at 3–4 months. There was no evidence of any deterioration in any and, indeed, one of the two who had previously exhibited some mild mental changes was now considered to have recovered fully. In none of the patients studied was there evidence of any disparity in flow either by inspection of the summated images or by graphic analysis. Radioangiography performed in one of the patients at this time revealed that there was no longer any evidence of a shift in the vessels (Fig. 3B). However, in the four subjects in whom the static brain scan had previously been positive, it remained so even though the intensity of the crescent was much less marked than in the earlier two studies (Fig. 4).

DISCUSSION

The static brain scan is an established procedure in the clinical evaluation of subdural hematoma and large series have been published (*8–18*). The crescent sign has been reported to be present in 81% of patients who were subsequently proven to harbor these lesions (*10*). Some evidence of the crescent sign tends to persist for longer periods than does the angiographic evidence of a subdural collection and indeed the crescent does not generally completely clear in nonsurgically treated patients by 6–12 months (*19*). This residual activity is mostly due to persistence in uptake in the collapsed membrane of the subdural.

A more serious difficulty in the use of static scanning in diagnosis is its lack of specificity. Although some relatively unusual intracranial lesions involving the meninges, such as extradural hematomas, subdural empyema, dural metastases, and pacymeningitis, may produce identical findings; the more common differential diagnosis problems arise in patients with recent head trauma. In such a situation it is often impossible to distinguish between the increased vascularity of extracranial lesions and the effect produced by superficial intracranial processes even though the comparison of early and late static scans occasionally may be helpful.

Experiences with rapid-sequence scintiphotography as a diagnostic aid is still limited and some of the reports have been equivocal. Fish, et al (*20*) as well as O'Mara and Mozley (*21*) were successful in demonstrating flow abnormalities in a few cases but Cowan and his coworker (*10*) failed to do so in a report of six cases. More recently, Hopkins and Kristensen (*22*) have presented a series of 42 patients studied by both rapid sequential scintigraphs and static scan and claimed to have a high degree of accuracy in delineating a subdural hematoma.

As far as we are aware, the use of rapid-sequence scintiphotographs has not previously been used to follow the course of nonsurgically treated patients. The present study demonstrates that it is not only a helpful, noninvasive method in suggesting the initial diagnosis but is a valuable aid in following the course of such patients when they are managed conservatively. Although it is possible to perceive large avascular regions in the "raw" scintiphoto, the use of a computer allowed us to use frame summation and smoothing to visualize smaller lesions with greater accuracy and reliability than would otherwise have been possible. Furthermore, the ability to generate time–activity curves in selected regions of interest allows one to document small but significant differences in flow. Also the flow curves become mandatory on followup studies at the 5–6 week and 14–16 week period because as the subdural decreases in size, it becomes difficult to assess the difference in the two sides by simple visual analysis.

It is unlikely that scintiphotography will replace radiographic angiography as the initial diagnostic modality in the approach to patients suspected of having a subdural hematoma. A positive, rapid-sequence scintiphotogram does not exclude the possibility that one is dealing with some other process that is expanding the subdural space other than a hematoma. However, once the diagnosis of a sub-

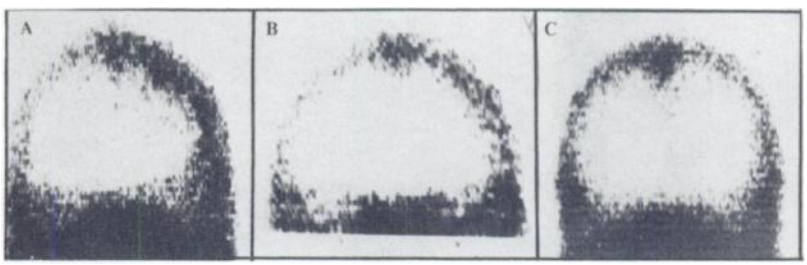

FIG. 4. Static brain scan with ^{99m}Tc-pertechnetate. Patient had head trauma 2 weeks previously. (A) Large crescent-shaped area of increased activity outlines subdural also demonstrated by angiography and rapid-sequence scintiphotogram. (B) Repeat scan at 12 weeks; crescent is still present but has less activity. (C) Scan at 7 months shows that activity over cerebral hemisphere is now symmetric.

dural hematoma is established by radiographic angiography, the rapid scintiphotogram has been found by us to be a useful supplemental method of following the course of the hematoma. A clear-cut reduction in the defect may avoid the risks and discomfort of repeated conventional angiography.

ACKNOWLEDGMENT

We would like to thank Morris B. Bender for his encouragement and interest in this study.

REFERENCES

1. BENDER MB: Recovery from subdural hematoma without surgery. *J Mt Sinai Hosp NY* 27: 52–58, 1960

2. BENDER MB: Resolution of subdural hematoma. *Trans Am Neurol Assoc* 85: 192–194, 1960

3. AMBROSETTO C: Post-traumatic subdural hematoma: Further observations on nonsurgical treatment. *Arch Neurol* 6: 287–292, 1962

4. SUZUKI J, TAKAKU A: Nonsurgical treatment of chronic subdural hematoma. *J Neurosurg* 33: 548–553, 1970

5. MCLAURIN RL, ISAACS E, LEWIS HP: Results of nonoperative treatment in 15 cases of infantile subdural hematoma. *J Neurosurg* 34: 753–759, 1971

6. GANNON WE, COOK AW, BROWDER EJ: Resolving subdural collections. *J Neurosurg* 19: 865–869, 1962

7. BENDER MB, CHRISTOFF N: Nonsurgical treatment of subdural hematomas. *Arch Neurol* 31: 73–79, 1974

8. JAFFE R, LIBROT IE, BENDER MB: Serial E.E.G. studies in unoperated subdural hematoma. *Arch Neurol* 19: 325–330, 1968

9. PEYTON WT, MOORE GE, FRENCH LA, et al: Localization of intracranial lesions by radioactive isotopes. *J Neurosurg* 9: 432–442, 1952

10. COWAN RJ, MAYNARD CD, LASSITER KR: Technetium-99m pertechnetate brain scans in the detection of subdural hematomas: a study of the age of the lesion as related to the development of a positive scan. *J Neurosurg* 32: 30–34, 1970

11. CIRIC IS, QUINN JL, BUCY PC: Mercury 197 and Technetium 99m brain scans in the diagnosis of non-neoplastic intracranial lesions. *J Neurosurg* 27: 119–125, 1967

12. MYERSON SB, WALTERS GS, REYNOLDS DH: Brain scans and subdural hematomas. *J Fla Med Assoc* 53: 291–295, 1966

13. GILDAY DL, COATES G, GOLDENBERG D: Subdural hematoma—what is the role of brain scanning in its diagnosis? *J Nucl Med* 14: 283–287, 1973

14. KRAMER S, ROVIT RL: The value of Hg^{203} brain scans in patients with intracranial hematomas. *Radiology* 83: 902–909, 1964

15. WILLIAMS CM, GARCIA-BENGOCHEA F: Concentration of chlormerodrin in chronic subdural hematoma. *Radiology* 84: 745–747, 1965

16. ZINGRESSER L, MANDELL S, SCHECHTER M: Gamma encephalograms in extracerebral hematomas. *Acta Radiol (Diag)* 5: 972–980, 1966

17. RABE EF, YOUNG GF, DODGE PR: The distribution and fate of subdurally instilled human serum albumin in infants with subdural collections of fluid. *Neurol (Minneap)* 14: 1020–1028, 1964

18. GILSON AJ, GARGANO FP: Correlation of brain scans and angiography in intracranial trauma. *Am J Roentgenol Radium Ther Nucl Med* 94: 819–827, 1965

19. LUSINS JO, KATZ J, BENDER MB: Long term follow-up of unoperated subdural hematoma by electroencephalography and static brain scans: unpublished data

20. FISH MB, POLLYCOVE M, O'REILLY S, et al: Vascular characterization of brain lesions by rapid sequential cranial scintiphotography. *J Nucl Med* 9: 249–259, 1968

21. O'MARA RE, MOZLEY JM: Current status of brain scanning. *Semin Nucl Med* 1: 7–30, 1971

22. HOPKINS GB, KRISTENSEN KAB: Rapid sequential scintiphotography in the radionuclide detection of subdural hematomas. *J Nucl Med* 14: 288–290, 1973