IMAGING PATTERNS OF SUBDURAL HEMATOMA— A PROPOSED CLASSIFICATION

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Eighteen patients with a total of 23 proved subdural hematomas presented four major discernible patterns on brain scan. A classification based on these patterns observed on the four conventional views is proposed. The various patterns of subdural hematomas were correlated with the clinical, radiographic, and surgical–pathologic findings. There were 13 instances of unilateral hematomas and 5 instances of bilateral lesions. Lesions showing a biconvex component as well as those of the band variety in general appear to correspond to older lesions. Lesions of the diffuse type appear to correspond to the early category. Unilateral lesions as a rule seem easier to discern on scan than bilateral ones. In the bilateral types the presence of a biconvex component is readily discernible on the straight projections and the corresponding lateral view may aid in its recognition. The bilateral band type should be suspected whenever both convexities appear unusually widened. The diffuse bilateral type appears to be more difficult to discern on scan. Delayed scanning is recommended in all patients clinically suspected of having subdural hematomas whenever the initial studies appear negative.

Angiographically, subdural hematomas appear either as crescentic or biconvex avascular zones (*1*). In 1956, Norman suggested that the crescentic defect indicated acute subdural hematoma and the biconvex connoted chronic lesions. A transitional shape was also described to correspond with an intermediate phase (*1*). However, chronic hematomas have been shown to assume either crescentic or biconvex configurations, casting doubt on the diagnostic reliability of these signs (*2,3*).

On the radionuclide brain scan, the crescent sign is considered a cardinal finding in subdural hematoma (*4–7*). This is manifested by an area of increased activity along the convexity of the inner calvarium as seen on the anterior or posterior scans. The crescent sign on scan does not differentiate between the two basic avascular zones seen on angiographic studies. Its presence is also by no means pathognomonic of subdural hematoma (*6,8,9*).

The purpose of this communication is to describe and classify the different scan patterns of subdural hematoma based on the four conventional scan views and to correlate the classified patterns with the clini-

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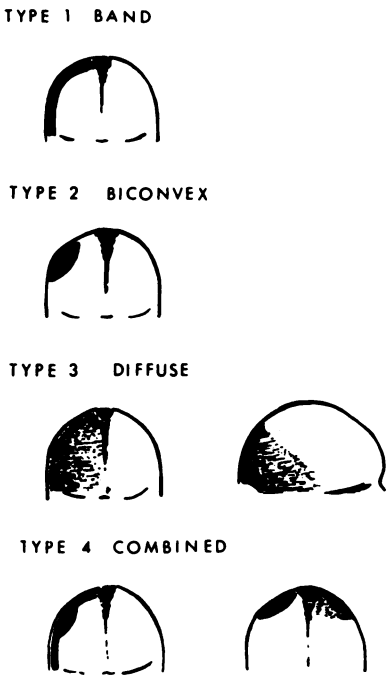

FIG. 1. Classification patterns of subdural hematoma on scan.

cal, radiographic, and pathologic aspects of each case (with particular emphasis on the age of lesion and the presence or absence of membrane formation.)

MATERIALS AND METHODS

The case records of all adult patients with subdural hematomas at the Brooklyn-Cumberland Medical Center from January 1970 to July 1973 were reviewed. This study is limited to 18 patients who had brain scans plus angiographic studies and/or surgery. All patients received 400–500 mg potassium perchlorate orally and 10–15 mCi ^{99m}Tc-pertechnetate intravenously before the scanning procedure. Scans were obtained with the Ohio-Nuclear dual probe scanner or the Picker dual Magnascanner, 30–60 min after the administration of radionuclide, except in one case a 2½-hr delayed study was also obtained. In most instances, all four conventional views were obtained except for four patients; in two instances posteriors could not be obtained and in two other cases lateral views could not be done.

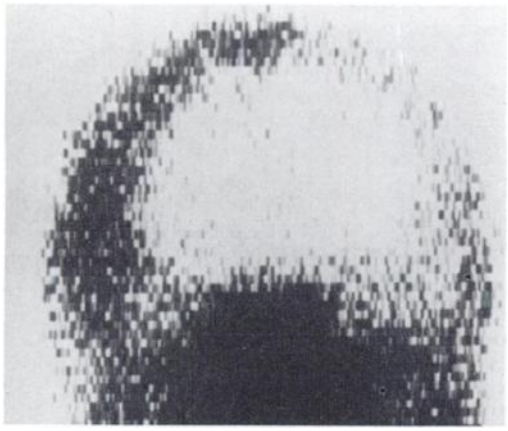

FIG. 2. Example of Type 1, band pattern (Case 3).

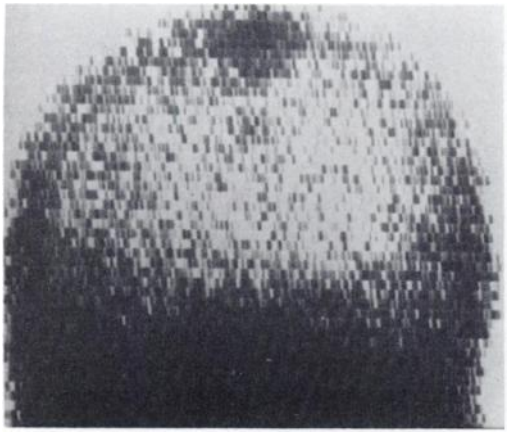

FIG. 3. Example of Type 2, biconvex pattern (Case 4).

SCAN PATTERN CLASSIFICATION OF SUBDURAL HEMATOMA

We observed in our series of brain scans four major patterns of subdural hematoma (Fig. 1). In this proposed classification based on the four conventional views, findings in the anterior and posterior views take precedence. When these views are negative as in one instance, then findings in the lateral projection attain primary significance.

Type 1 (band). The anterior and/or posterior scans outline a curvilinear band of increased radioactivity that parallels the convexity of the inner calvarium (Fig. 2). This terminates abruptly in the midline except when a contralateral hematoma is also present. The lateral view may sometimes show relatively increased diffuse radioactivity but more often it yields negative findings. This type is either unilateral or bilateral.

Type 2 (biconvex). A biconvex area of increased radioactivity may be present anywhere along the subjacent convexity, usually in the middle third, but may be situated close to the sagittal sinus or at the medial base of the convexity. This type is well defined on anterior and/or posterior views depending on the hematoma site. It is often localized on the lateral view as well. This is also either unilateral (Fig. 3) or bilateral.

Type 3 (diffuse). This type may be seen in any of the four conventional views as an area of increased diffuse radioactivity on the side of the lesion. The anterior or posterior scan may show an area of diffuse radioactivity that gradually tapers off towards the midline. It lacks the increased well-delineated radioactivity observed in the first two types. Occasionally, the radioactivity may be confined to the lateral view alone. Cases in this category were unilateral, except for one (Figs. 4 and 5).

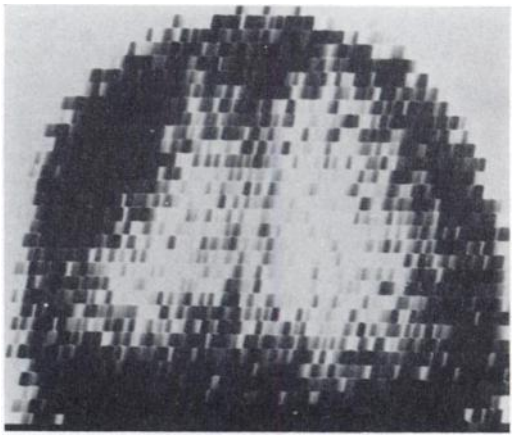

FIG. 4. Example of Type 3, diffuse pattern (Case 2). Note relative increased radioactivity in the right side, tapering off toward midline.

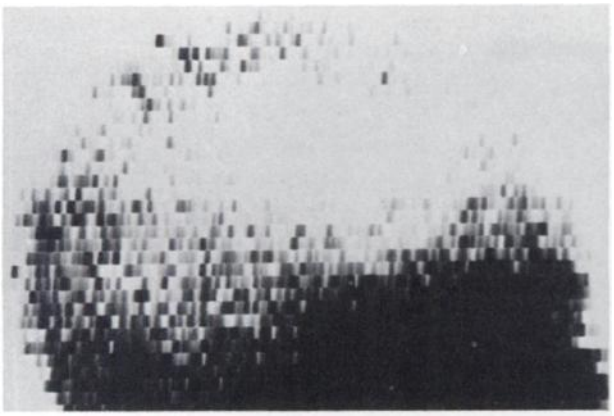

FIG. 5. Unusual localization of activity in occipitoparietal area on lateral projection alone. Straight views were negative (Case 14).

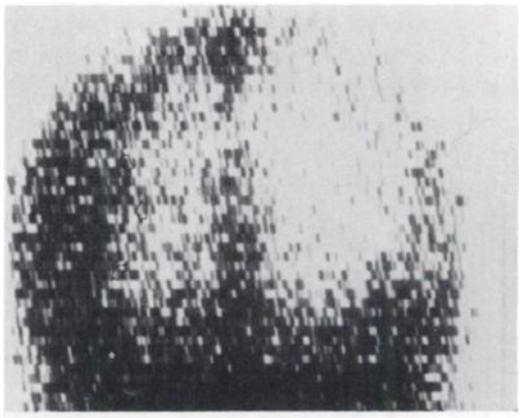

FIG. 6. Combined type, biconvex-band activity on right side.

Type 4 combined. *Types 1 and 2 combined pattern.* The unilateral presence of biconvex and curvilinear band activity is seen on either the anterior or posterior view. The biconvex activity may be localized in the upper, middle, or lower thirds of the curvilinear band (Fig. 6). Another variant is the presence of a biconvex pattern in the anterior view and the curvilinear band pattern on the posterior view of the same side, or vice versa.

Types 2 and 3 combined pattern. This is a bilateral pattern where one side manifests a biconvex pattern and the contralateral side yields a diffuse one. Theoretically a combination of Types 1 and 3 is also possible but we did not observe this in our series.

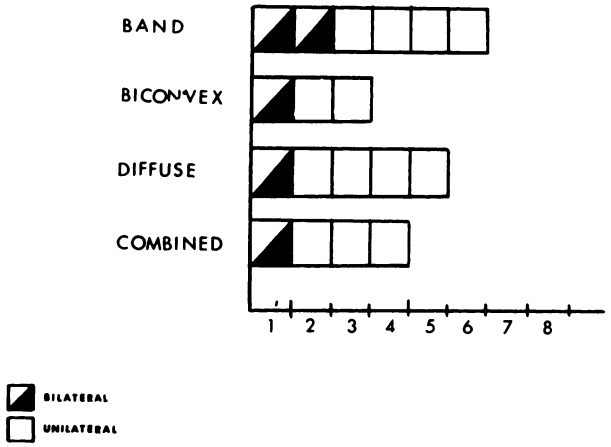

FIG. 7. Breakdown of 18 cases into different types.

DISCUSSION

Eighteen patients with 23 proved subdural hematomas presented a variety of major discernible scan patterns (Table 1). Of these only eight patients had a definite history of prior trauma. Although five others had a history of fall or loss of consciousness on the day of admission, in at least three cases this immediate event did not appear to have been the cause of the subdural hematoma since the surgical findings indicated lesions of longer standing. The absence of a history of trauma in a number of patients is not unusual (*2,4,10*). This is in part explained by the poor or unreliable histories which may be obtained from the aged and alcoholics. Figure 7 shows a breakdown of the cases into the different categories of scan pattern.

Of the 23 subdural hematomas, 14 (Cases 1, 2, 4, 9, 11, 14, 15, 16, 17, and 18) had specific reference to the presence or absence of membrane formation either at surgery or on microscopic study Cases 9, 15, 16, and 18 have two lesions (Table 2). Of these 14 lesions, nine instances (Cases 1, 4, 9, 11, 15, 16, and 17) disclosed thick organized fibrous membrane of which five were of the biconvex type and four were of the band type (Fig. 8A). Two lesions (Cases 2 and 18), both of the diffuse type, showed a thin organizing membrane (Fig. 8B). In three other lesions (Cases 9, 14, and 18), all of which were of the diffuse type, no membrane formation was established. Cowan, Maynard, and Lassiter (*5*) not only emphasized the reliable correlation of a positive scan with the presence of a well-formed membrane but also indicated that neovascularization in the organizing membrane (which probably occurs after the tenth day of trauma) permits a more permeable passage of the ^{99m}Tc-pertechnetate into the subdural fluid. Mealy (*11*) provided supporting evidence in animal studies by showing higher concentrations of isotopic activity in the subdural membrane than in the more inert contents of the hematomas or subjacent cerebral cortex. Other investigators have also observed that in certain instances the activity in the fluid contributes to or accounts for the positive finding in the scan (*12,13*). However, in

Case 9, which was bilateral, the right-sided biconvex uptake on scan was due to a completely resolved hematoma with a thickened empty sac. At least in this instance no apparent fluid activity contributed to the scan finding.

Of the various patterns described, the diffuse type appears to be the least specific and most equivocal. It can easily be caused by a superficial hematoma or a cerebral contusion. Case 9, which disclosed a biconvex lesion on one side, also had a contralateral diffuse lesion which was not initially suspected on scan. It was later suggested on angiographic studies by the lack of shift of the anterior cerebral arteries. Case 18, which was a bilateral diffuse lesion, became suspect only on the 2½-hr delayed scan. The initial scan was completely unremarkable. Others have also observed and stressed the importance of performing a delayed scan in this situation because of the latter's increased positivity (*14*). Case 14 presented an unusual scan localization. The anterior and posterior scans were completely unrevealing and only the right lateral showed diffuse activity in the occipital region (Fig. 5). The seven examples of diffuse pattern in our series appear to correspond with "early" lesions, both by history and surgical tissue findings. We concur with Cowan and colleagues in the use of the terms "early" and "older" when referring to the age of a subdural hematoma (*5*). The terms "acute" and "chronic" convey different time relationships to different physicians and surgeons and are vague and

TABLE 1. CLINICAL, SCAN, ANGIOGRAPHIC, AND SURGICAL–PATHOLOGIC CORRELATIONS

Cases	Age and sex	History	Type	Angiogram	Surgical and tissue findings
1	74M	Head trauma 60 days before admission	4A-unilateral	Transitional	Dark fluid; clots with calcium deposits. Thick membrane
2	84F	Head trauma 10 days before admission	3-unilateral	Transitional	120–150 cc dark fluid and clots. Thin blue membrane
3	69F	Car accident 35 days before admission	4A-unilateral	Transitional	Yellowish pink fluid. No mention of membrane
4	68M	Fall 12 days before admission	2-unilateral	Biconvex	50 cc dark fluid. Thick fibrous membrane
5	23M	Trauma 8 days before	4A-unilateral	Crescent	Refused surgery
6	63M	No history of trauma	3-unilateral	Biconvex	120 cc dark "oily" fluid. No mention of membrane
7	52M	Alcoholic; unconscious on admission	1-unilateral	Crescent	Refused surgery
8	54F	Headache 5 days before. No history of trauma	1-unilateral	Crescent	150–200 cc black fluid. No mention of membrane
9	77M	Fall on day of admission	4B-bilateral	R—biconvex. L—not done—(unshift ant. cerebral arteries)	L—25 cc blood clot, no membrane found; R—empty fibrous sac
10	76M	Unconscious on admission	1-bilateral	Crescent (both)	R—60–70 cc of yellowish fluid. L—30 cc fluid and clots with calcium deposits. No mention of membrane
11	62M	Admitted in semicoma	2-unilateral	Biconvex	30 cc of yellowish fluid. Thick fibrous membrane
12	42M	Head trauma 12 days before scan	1-unilateral	Crescent	No surgery. Discharged asymptomatic
13	45M	No history of trauma	3-unilateral	Crescent	40 cc dark fluid. No mention of membrane
14	41F	"Blacked out" on admission	3-unilateral	Crescent	75 cc of fresh blood clot. No membrane noted
15	60F	Fall on day of admission	1-bilateral	Transitional	R—10–20 cc dark fluid; thick dura. L—15–20 cc dark fluid; thick fibrous membrane
16	43M	Alcoholic; head trauma years ago	2-bilateral	Biconvex (both)	R and L—dark fluid. Thick fibrous membrane (both)
17	79M	No history of trauma; "stroke" 28 days before	1-unilateral	Crescent	20 cc "oily" fluid; blood clots; hemorrhagic cyst; thick fibrous membrane
18	55M	Car accident 10 days before admission	3-bilateral	R—crescent. L—not done—(unshift ant. cerebral arteries)	R—60 cc bloody fluid; no membrane noted. L—55 cc bloody fluid and clots; dura showed early organizing membrane

TABLE 2. CORRELATION WITH MEMBRANE FORMATION

24 lesions of subdural hematoma (18 patients)	
14 lesions—specific reference to presence or absence of membrane	
9 lesions showed thick membrane	
5 lesions—biconvex	
4 lesions—diffuse	
2 lesions showed thin membrane	
2 lesions—diffuse	
3 lesions—no membrane found	
3 lesions—diffuse	
6 lesions—no specific reference	
3 lesions—no surgery	

confusing as a consequence (*10,15,16*). Our definition of "early" refers to lesions before the 12th day of trauma and "older" to lesions after this period.

Two patients refused surgery and one was discharged completely asymptomatic. They are retained in the study because their clinical courses were suggestive and the scan and angiographic studies were unequivocal. Cases of proved subdural hematoma that have spontaneously resolved without the benefit of surgery have been documented previously (*17,18*). Two of our three cases that had no surgery showed a band pattern on scan. Cases 8, 10, 15, and 17 were also of the band variety. The latter two both had bilateral hematomas and are probably older lesions because of the calcium deposition in one of the hematomas in Case 10 and the presence of bilateral thickened fibrous membranes in Case 15. The latter had only 10–20 cc of dark fluid evacuated from each lesion. This small quantity of fluid may well have influenced the extent and pattern of scan.

In subdural hematomas, it is the consensus that lateral scans yield minimal or no additional data despite the presence of abnormal activity on the anterior or posterior scans (*4,19*). This is because the scanning probe is directly perpendicular to the hematoma on the lateral view whereas on the anterior or posterior view it is tangential to the lesion. Arkles and associates (*4*) suggested that whenever the lateral projection shows some minimal increased activity corresponding to a suspected side, this should be regarded as a positive finding. In our series, seven patients showed negative lateral studies. Laterals could not be obtained on two patients, and on five others light-to-heavy diffuse radioactivity was noted. Case 15 had a streak of increased radioactivity. However, three other cases (5, 11, and 17) of the biconvex variety outlined abnormal well-localized radioactivity on the lateral view. On the whole, the lateral views yield less information, particularly in the diffuse variety. An exception to this is Case 14.

At times bilateral subdural hematomas, because of their balanced activity, may appear falsely negative on scan (*7,20*). Of the different patterns described, in our experience the bilateral diffuse pattern appears to be the most difficult to recognize on scan. Case 18 is such an example. We have encountered four other cases with bilateral lesions in this series. Bilateral biconvex subdural hematomas probably present the least difficulty in interpretation because of the characteristic shape of the abnormal radioactivity. Furthermore, the corresponding lateral view may also outline the lesions. Bilateral band type should be suspected whenever the curvilinear radioactivity on both sides appears unusually thickened and increased. In our two band cases, the lateral views were less helpful, although Case 15 showed a streak of increased uptake on one side and diffuse parasagittal uptake was noted in Case 10.

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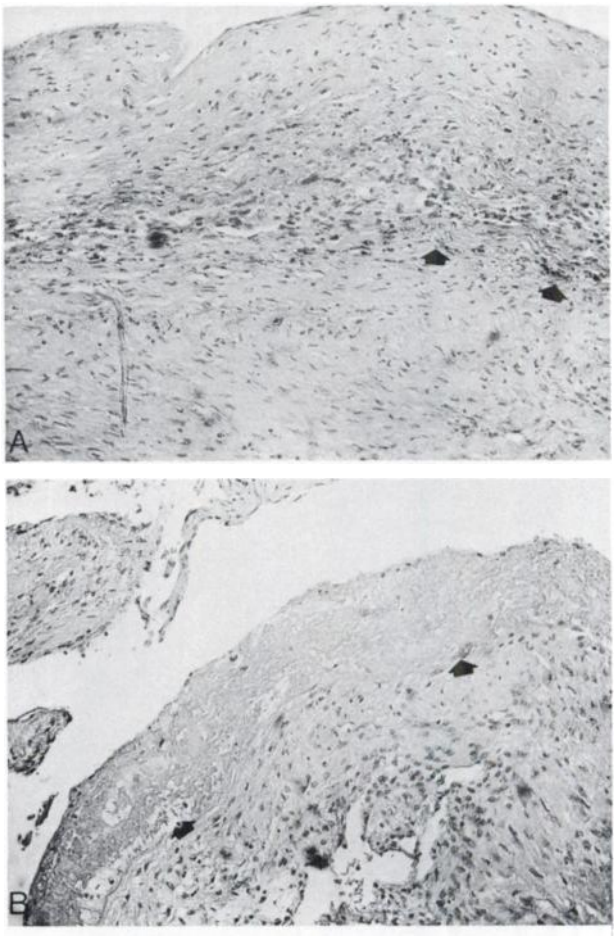

FIG. 8. (A) A section of dura and old organized blood clot. Junction between organized clot and dura is barely discernible. Arrows point to deposits of hemosiderin pigment (Case 4). (B) Section of dura with early organizing blood clot. Arrows point to junction between clot and dura (Case 18).

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