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Subarachnoid Hemorrhage Secondary to Ruptured Intracranial Aneurysm:

Prognostic Significance of Cranial CT

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Computed tomographic (CT) findings in 50 patients with subarachnoid hemorrhage due to proven intracranial aneurysms were analyzed for prognostic significance in relation to the clinical grade and severity of vasospasm that developed preoperatively. Only patients who had CT within 4 days after the documented hemorrhage were included in the study. CT scans were classified according to the extent of subarachnoid bleeding. There was direct correlation between the extent of blood and the clinical grade, and between the extent of blood and the severity of vasospasm that developed. The importance of abnormal contrast enhancement was also investigated and found to be of no significance. Scans soon after subarachnoid hemorrhage can assist in identifying patients at risk for preoperative neurologic deterioration.

Computed tomography (CT) has proven to be of great value in patients with subarachnoid hemorrhage due to ruptured intracranial aneurysms. Aside from its role in the detection of subarachnoid blood, its uses include prediction of aneurysm location and identification of complications, such as hydrocephalus, recurrent bleeding, infarction, and extracerebral, intracerebral, and/or intraventricular blood [1–9]. Potentially hazardous lumbar puncture may also be avoided. In addition, it provides a means by which the extent of blood in the subarachnoid space can be measured. It might be expected that the extent of bleeding would correlate with the preoperative clinical grade and severity of vasospasm. We studied these factors in 50 patients in an attempt to evaluate the prognostic significance of CT.

Materials and Methods

The study comprised 50 patients from the Neurosurgical, Neuromedical and Stroke Services of Massachusetts General Hospital. There were 35 women and 15 men aged 22–73 years. Patients with more than one documented subarachnoid hemorrhage were not included. Day 1 was defined as the day of the bleeding.

The CT scans were classified according to the anatomic extent of subarachnoid blood (figs. 1–3). Class 1 = no subarachnoid blood; class 2 = minimal subarachnoid blood (Sylvian fissure(s) and/or interhemispheric fissure); class 3 = moderate subarachnoid blood (Sylvian fissure(s), and/or interhemispheric fissure, and suprasellar cistern); and class 4 = extensive subarachnoid blood (Sylvian fissure(s), interhemispheric fissure, suprasellar cistern, and ambient cistern). Only patients who had scans within 4 days after documented hemorrhage were included in the study. All scans were interpreted independently by two neuroradiologists who later compared their results for intra- and interobserver error. No errors were found. Scans were performed on an EMI 1005 head scanner with a 180 × 180 matrix. Contrast-enhanced scans were obtained in 24 patients. A 300 ml infusion of meglumine diatrizoate (Reno-M-DIP, Squibb) 200 ml of sodium iothalamate

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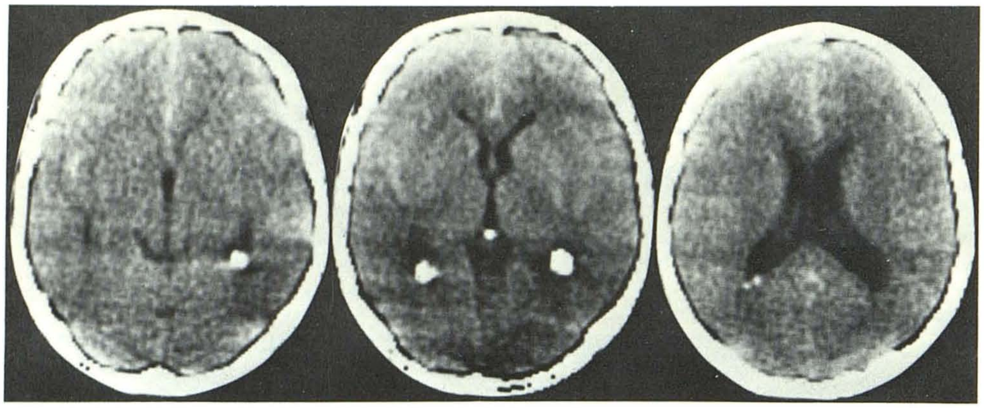

Fig. 1.—Class 2. Blood limited to Sylvian fissures and anterior interhemispheric fissure (nonenhanced).

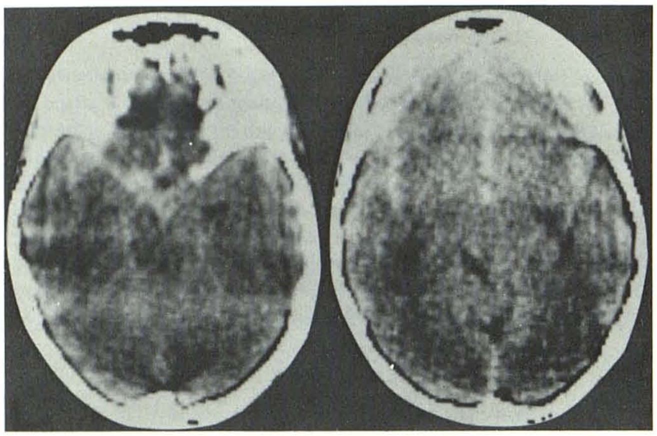

Fig. 2.—Class 3. Blood in suprasellar cistern, Sylvian fissures, and anterior interhemispheric fissure (nonenhanced).

(Conroy 400, Mallinckrodt) or sodium and meglumine diatrizoate (Renografin-76, Squibb) was used. The contrast-enhanced scans were evaluated for a localized or diffuse gyral enhancement pattern (figs. 4 and 5).

We evaluated the clinical grades during the preoperative period and recorded the worst grade of the patient during this time. We used a modified Botterell classification [10]: grade I = no neurologic deficit; grade II = alert, minimal neurologic deficit; grade III = drowsy or confused, stiff neck, with or without neurologic deficit; grade IV = semicomatose, with or without deficit; and grade V = comatose, decerebrate.

Selective transfemoral carotid and vertebral arteriography with ×1.6 magnification and subtraction technique was performed in all patients. Two patients had arteriography before 4 days after bleeding. These patients were not evaluated since the likelihood of spasm during this period is low [11]. The other 48 patients had arteriography after day 4. Arteriographic spasm was graded according to a classification used by Fisher et al. [12] at our institution. In that classification, 0 = no narrowing; 1+ = diameter greater than 1 mm; 2+ = diameter less than 1 mm; 3+ = diameter greater than 0.5 mm, indistinct vessel outline, delayed forward flow; and 4+ = diameter less than 0.5 mm, forward flow almost halted. We recorded the worst vasospasm detected angiographically during the postoperative period.

Results

There were 11 patients with a class 1 scan, 17 with class 2, five with class 3, and 17 with class 4.

Aneurysm Location and CT Class

We discovered no relation between aneurysm location and CT class. The data on aneurysm location versus extent of subarachnoid blood are shown in table 1.

CT Class and Worst Preoperative Clinical Grade

Table 2 summarizes the relation between the extent of subarachnoid blood and the patient's worst preoperative grade. The 25 of 28 patients with no or minimal subarachnoid blood present (class 1 or 2 scans) became no worse than grade III. Of the 22 patients with class 3 or 4 scans, 11 became grade IV or V. Five patients remained grade I during the entire preoperative course; four had either a class 1 or 2 scan. There were 12 patients who became no worse than grade II; nine had a class 1 or 2 scan. There were 36 patients who became no worse than grade III; 25 had either a class 1 or 2 scan. Of the 14 patients who became grade IV or V, 11 had a class 3 or 4 scan.

CT Class and Severity of Spasm

Table 3 summarizes the relation between CT class and severity of preoperative vasospasm detected angiographically. Of the 28 class 1 or 2 CT patients, 19 developed no worse than 1+ spasm. Of the 20 class 3 or 4 patients, 14 who had arteriography at an appropriate time to evaluate spasm developed severe (3+ or 4+) spasm. There were 22 patients who developed 3+ or 4+ spasms; 14 of these had class 3 or 4 CT scans. Of the other eight patients, five had a class 2 scan and three had a class 1 scan. Of 24 patients who had 0 or 1+ spasm, 19 had class 1 or 2 CT scans.

Significance of Contrast Enhancement

We believe there was little relation between abnormal enhancement and severity of clinical grade and spasm. Of the 50 patients, 24 had contrast-enhanced scans. An abnormal localized gyral enhancement pattern was seen in three and a diffuse gyral enhancement was seen in three. This may be due to irritation of the meninges from subarachnoid blood. In three patients there was no abnormal enhancement other than identification of the aneurysm, and there was no abnormal enhancement in the other 15.

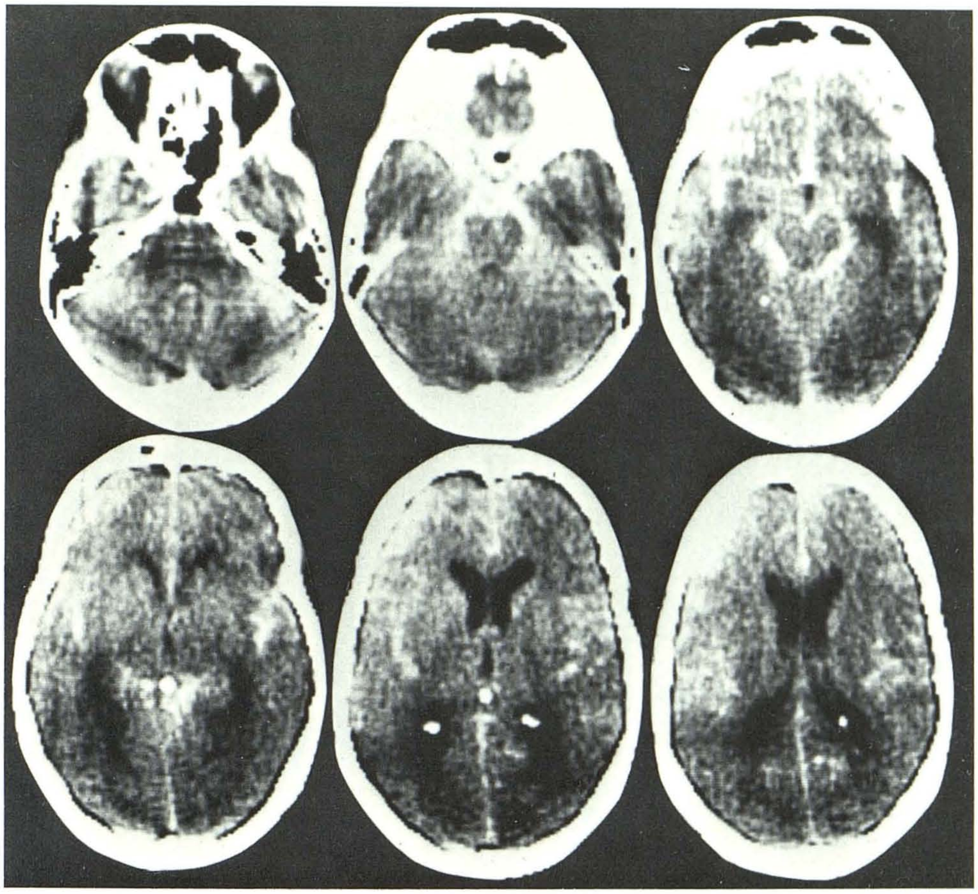

Fig. 3.—Class 4. Blood in Sylvian fissures, suprasellar cistern, interhemispheric fissure, and ambient cisterns (nonenhanced).

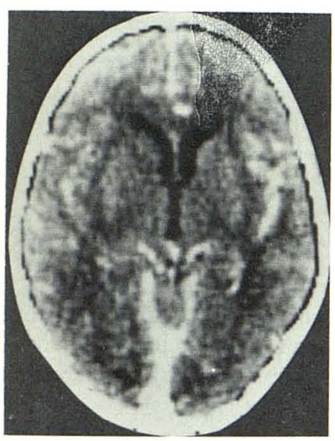

Fig. 4.—Localized abnormal enhancement in Sylvian fissure.

Significance of Intraventricular and/or Intraparenchymal Blood

We explored the relation between the presence of intraventricular and/or intraparenchymal blood and the severity of the clinical grade and spasm encountered preoperatively. Intraventricular and/or intraparenchymal hematomas were present in 15 patients. No relations were found between the presence of the hematomas and the clinical grade or presence of spasm.

Discussion

We found a loose correlation between the extent of subarachnoid blood and the severity of clinical grade encountered preoperatively. There were 28 patients with a class 1 or 2 scan (no or minimal subarachnoid blood) and 22 patients with a class 3 or 4 scan (moderate or extensive subarachnoid blood). The correlation was closer for the patients without or with only mild clinical deficits than for the patients with more severe deficits.

Of the 28 class 1 or 2 patients, 25 (89%) became no worse than grade III. Of the 22 class 3 or 4 patients, 11 (50%) became grade IV or V. Of the 14 patients who deteriorated to grade IV or V, 11 had a class 3 or 4 scan. In the three instances without good correlation (class 1 or 2 scan deterioration to grade IV or V), neither severe spasm nor intraventricular or intraparenchymal hemorrhages seemed to be causative factors. The discrepancy may have been due to: (1) brain damage from hydrocephalus or hypothalamic disturbance or (2) underestimation of the extent of the subarachnoid hemorrhage. Of 12 patients who remained grade I or II, nine had a class 1 or 2 scan. No explanation can be offered for the three patients with class 3 or 4 scans who only became no worse than grade I or II.

There was a more direct correlation between the extent of the subarachnoid blood and the severity of the spasm in the preoperative period. Of the 28 class 1 or 2 patients, 20 (71%) developed no worse than 2+ spasm. Of the 20 class

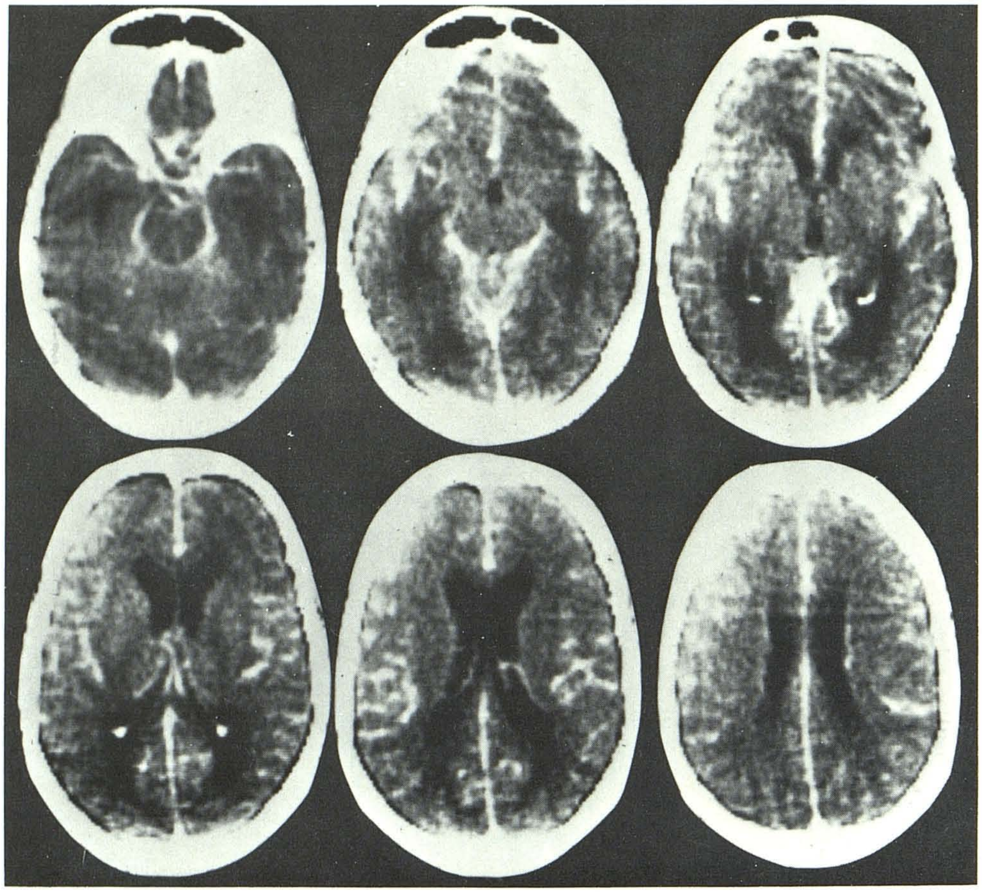

Fig. 5.—Diffuse abnormal enhancement (same case as fig. 3).

TABLE 1: **Relation Between CT Class and Aneurysm Location**

Artery	CT Class*			
	1	2	3	4
Anterior communicating	1	7	4	2
Posterior communicating	6	3	0	6
Middle cerebral	1	2	0	4
Internal carotid	2	1	0	0
Ophthalmic	0	1	0	0
Pericallosal	0	2	0	2
Basilar	0	1	0	2
Posterior inferior cerebellar	1	0	1	0
Superior cerebellar	0	0	0	1

* See Materials and Methods.

TABLE 2: **Relation Between CT Class and Clinical Grade**

CT Class*	Grade* (No. Patients)					Total
	I	II	III	IV	V	
1	2	2	6	0	1	11
2	2	3	10	0	2	17
3	0	1	1	2	1	5
4	1	1	7	0	8	17

* See Materials and Methods.

3 or 4 patients, 14 (70%) developed severe (3+ or 4+) spasm. Of 22 patients who developed 3+ or 4+ spasm, 14 had a class 3 or 4 scan. Of 24 patients with 0 or 1+ spasm, 19 had a class 1 or 2 scan. In those class 3 or 4 patients

TABLE 3: **Relation Between CT Class and Severity of Spasm**

CT Class*	Severity of Spasm*					Totals
	0	1+	2+	3+	4+	
1	3	5	0	1	2	11
2	8	3	1	5	0	17
3	1	0	1	2	0	4
4	2	2	0	6	6	16

* See Materials and Methods.

who showed little or no spasm on arteriography, the poor correlation may have been due to the timing of the angiography, which may have been done when the vasospasm was not at its worst clinical stage.

Our CT classification is based on the anatomic extent of subarachnoid blood, rather than the quantitative density (attenuation coefficient values), since density is subject to variables such as progressive isodensity with time and partial-volume effect. One limitation is that this classification does not allow distinction between large and small collections of blood in a specific subarachnoid compartment. Its advantages include reliable reproducibility by the same or different observers.

We attempted to determine whether CT can identify subarachnoid hemorrhage patients at risk for neurologic deterioration in the preoperative period. Our preliminary results indicate that CT is useful as a prognostic indicator in the subarachnoid hemorrhage patient. Since our series was rather small, the results will have to be reassessed for a larger group of patients, including prospective analysis. Hopefully, CT will prove to be a useful guide for medical and surgical management of the patient with subarachnoid hemorrhage. This management might include: (1) prophylaxis for vasospasm with volume loading and drug therapy with dopamine or nitroglycerine and (2) early surgery for aneurysm obliteration to permit hypertension therapy and remove periarterial clot.

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