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Trauma

Can midline brain shift be used as a prognostic factor to predict postoperative restoration of consciousness in patients with chronic subdural hematoma?

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Abstract

Background and Purpose: Our aim was to determine if midline brain shift could be used as a prognostic factor to predict postoperative restoration of consciousness in patients with CSDH. In these patients, we evaluated the relation (1) between midline brain shift as measured on CT and alteration of level of consciousness, and (2) between midline brain shift and restoration of consciousness after the operation.

Methods: Prospectively recorded data of 45 patients with CSDH were evaluated. We compared level of consciousness of patients measured by GCS score, brain displacement at PG and SP both in the preoperative and early postoperative period.

Results: Preoperatively, PG and SP shifts of the patients who were alert (GCS = 15) were significantly less than those of patients who had diminished consciousness. However, in patients with diminished consciousness (GCS < 15), the amount of lateral brain displacement and the degree of diminution of consciousness did not correlate. Those patients who had a preoperative SP shift of less than 10 mm had a significantly lesser chance to become alert after operation (2 of 5 patients) when compared with those patients who had a preoperative SP shift of 10 mm or more (21 of 23 patients).

Conclusions: We conclude that preoperative SP shift may be used as a factor to predict restoration of consciousness in patients with CSDH; the likelihood of becoming alert after operation is increased if SP shift is 10 mm or greater, and is decreased if SP shift is less than 10 mm.

Keywords: Chronic subdural hematoma; Brain shift; Restoration of consciousness

1. Introduction

The decision to operate is not always easy in patients with CSDH, which is usually encountered in the elderly. Although surgery is simple and has satisfactory results in CSDH, even a minor surgical procedure may be harmful to these patients because of the accompanying hemodynamic and pulmonary disturbances. Altered consciousness is among the most common features of CSDH in older patients besides headache, ataxia, and hemiparesia [1]. In these patients, restoration of consciousness and elimination of other symptoms is expected after evacuation of hemorrhage. However, in elderly patients, diminished consciousness and other symptoms might also be related to disturbances other than hemorrhage, such as metabolic encephalopathy, Alzheimer disease, Parkinson disease, concurrent stroke, multi-infarct dementia, senile dementia, and reversible ischemic deficits. For the management of a patient, it is essential to know if the symptoms and findings

Abbreviations: CSDH, chronic subdural hematoma; CT, computed tomography; GCS, Glasgow Coma Scale; PG, pineal gland; MRI, magnetic resonance imaging; SP, septum pellucidum.

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are related to direct compression of subdural hemorrhage and if the patient would benefit from the operation. Postoperative prognosis should be predicted by a simple bedside method based on objective criteria. Although intracranial pressure monitoring and MRI [3] have been used to predict prognosis, CT is the method of choice because it is a widely available, fast, and simple technique. In patients with CSDH, the decision to operate and determination of prognosis may be based on width and volume of hemorrhage and the degree of midline shift as measured on CT scans. However, it is more reasonable to evaluate midline brain shift rather than volume of hemorrhage to estimate if the patient will recover after the operation, because the midline brain shift shows that hemorrhage has filled up the potential space in the cranium and has exerted compression on the brain tissue.

Our aim was to determine if midline brain shift could be used as a prognostic factor to predict restoration of consciousness in patients with CSDH. In a homogeneous group of patients with CSDH, we evaluated the relation (1) between midline brain shift as measured on CT and alteration of level of consciousness, and (2) between midline brain shift and restoration of consciousness after the operation. To our knowledge, this is the first study evaluating the relation between midline brain shift and restoration of consciousness in the early postoperative period in patients with CSDH.

2. Subjects and methods

Prospectively recorded data of 45 patients with CSDH were evaluated. These patients were operated on between October 2002 and June 2004 by either burr-hole or twist-drill craniostomy, avoiding major surgical procedures such as craniotomy or craniectomy. There were 35 men and 10 women (age range, 35-98 years; mean, 69 ± 13 years). We evaluated the level of consciousness of patients by GCS score and found diminished consciousness in 28 patients. Ten patients with paresis, 6 patients with headache, and 1 patient with truncal ataxia did not have diminished consciousness.

Brain displacement at the PG and SP, both in the preoperative and early postoperative period, was measured by the radiologist (FG), who was blinded to the clinical status of the patients. PG shift and SP shift were calculated on CT as the distance from the center of PG calcification and from a point between the anterior horns of lateral ventricles to a perpendicular line connecting the anterior and posterior insertions of the falx cerebri. Measurements for all scans from an individual patient were made on the slice that PG and lateral ventricles could be seen at the same time. We reevaluated the patients in the early postoperative period (2 to 4 days after operation just when drainage catheters were withdrawn) rather than determining the outcome several months after operation for several reasons. First, death and recurrent subdural hemorrhage is not expected in this period; therefore, all the patients would be available for the second evaluation. Second, within a few days, there is little chance for the accompanying diseases to change the patient's level of consciousness. Third, this is the only period in which the change in the patient's level of consciousness can be attributed to the evacuation of hematoma. Variables were analyzed by Student *t* test, Mann-Whitney *U* test, and χ^2 test (Fischer exact test). Values are shown as mean ± SD.

3. Results

Preoperative and postoperative GCS scores, SP shifts, and PG shifts of all patients are shown in Table 1.

In the preoperative period, SP shifts ranged between 0 and 22 mm (11.4 ± 5.2 mm), and PG shifts ranged between 0 and 14 mm (6.7 ± 3.5 mm). Preoperatively, PG and SP shifts of the patients who were alert (GCS = 15) were less than those of patients who had diminished consciousness (GCS = 4-14). The difference between SP shifts was statistically significant, whereas the difference between PG shifts was at the limit of statistical significance (Table 2). However, in the group of patients who were not alert (GCS <15), subgroups (GCS = 4-12 vs GCS = 13, 14) did not show any statistically significant difference regarding the amount of lateral brain displacement (Student *t* test, P = .432 for SP shift and P = .118 for PG shift).

In the postoperative period, the decrease in SP shifts ranged between 0 and 12 mm (5.5 ± 3.0 mm), and the decrease in PG shifts ranged between 0 and 7 mm (3.4 ± 2.1 mm). These values corresponded to approximately 50% decrease of shifts after operation. Seventeen patients who were alert (GCS = 15) before operation remained alert after operation; these patients were not included in the statistics related to the calculation of restoration of consciousness postoperatively. The patient with truncal ataxia (no. 6) recovered after operation. Of 10 patients with hemiparesis, the finding disappeared in 9 patients and decreased in 1 patient (no. 8). In this patient, there was no PG or SP shift preoperatively. Of 6 patients with headache, this symptom disappeared in half of patients and decreased in the other half. Preoperative SP and, especially, PG shifts of the patients whose headache disappeared after operation were higher than those of patients whose headache did not disappear, although this difference did not reach statistical significance.

Preoperative SP shifts of patients who had complete restoration of consciousness were higher (13.65 ± 3.45) than those of patients who did not become alert after operation (8.40 ± 9.32), although the difference did not reach statistical significance (Mann-Whitney *U* test, P = .147). In addition, there was no statistically significant difference between the patients who did and did not become alert after operation regarding preoperative PG shifts (Mann-Whitney *U* test, P = .292). Those patients

Table 1
Preoperative and postoperative GCS scores, SP shifts, and PG shifts of all patients (sorted by preoperative GCS)

No.	Age	Sex	Preoperative			Postoperative		
			GCS	SP	PG	GCS	SP	PG
41	83	F	4	4	3	4	2	2
5	80	M	9	0	0	14	0	0
15	58	F	9	15	5	15	10	4
29	76	M	9	22	14	14	12	7
36	47	M	9	16	8	15	8	6
4	79	M	10	14	10	14	4	3
2	83	M	11	2	2	14	2	1
20	73	F	11	17	14	15	7	8
35	64	M	11	15	7	15	11	4
40	98	F	11	5	3	15	2	0
10	35	M	12	16	7	15	8	3
12	45	M	12	16	6	15	11	3
24	77	F	12	12	5	15	6	4
31	83	M	12	13	6	15	6	4
1	73	M	13	15	9	15	4	3
16	84	M	13	7	5	15	2	0
17	83	M	13	16	10	15	6	4
18	70	M	13	16	11	15	9	7
25	83	F	13	11	4	15	3	1
26	65	M	13	14	8	15	9	4
27	80	M	13	15	10	15	9	6
30	75	M	13	12	11	15	10	7
13	66	M	14	11	8	15	6	2
21	51	M	14	13	6	15	9	5
34	86	F	14	12	7	15	4	2
37	55	M	14	16	12	15	11	5
43	75	M	14	21	11	15	9	5
45	70	M	14	10	7	15	6	4
3	47	M	15	15	5	15	8	3
6	69	M	15	9	6	15	2	2
7	74	M	15	7	2	15	3	0
8	76	M	15	0	0	15	0	0
9	67	M	15	6	3	15	4	3
11	44	M	15	6	2	15	3	0
14	66	M	15	15	11	15	9	6
19	66	M	15	18	8	15	8	3
22	48	F	15	12	9	15	7	5
23	75	F	15	5	3	15	0	0
28	65	M	15	7	3	15	6	3
32	50	F	15	11	8	15	6	5
33	73	M	15	5	4	15	3	2
38	59	M	15	12	7	15	4	3
39	71	M	15	11	9	15	7	4
42	74	M	15	5	2	15	2	0
44	66	M	15	13	9	15	8	2

who had a preoperative SP shift of less than 10 mm had a significantly lesser chance of becoming alert after operation when compared with those patients who had a preoperative SP shift of 10 mm or more (Fischer exact test, $P = .027$) (Table 3).

4. Discussion

The relation between midline brain shift caused by intracranial abnormalities and diminution of consciousness [5,7], and the relation between midline brain shift and restoration of consciousness in the postoperative period [5] have been studied before. However, the study groups were heterogeneous in these reports, consisting of patients with various intracranial abnormalities. Furthermore, they included patients with acute lesions, excluding those with chronic pathologies. Inao et al [3] have evaluated the relation between midline brain shift, hematoma thickness, and brain rotation angle as measured on MRI, and clinical signs and symptoms as well as local cerebral blood flow in a homogeneous group of patients with CSDH. They have not, however, evaluated the patients in the postoperative period. Although Havenbergh et al have correlated size of the hematoma and midline shift on preoperative CT with overall outcome at the time of discharge in patients with CSDH [2], they have not determined the influence of operation on the level of consciousness of patients in the early postoperative period.

A relationship between increasing midline brain shift and diminished consciousness have been found in acute unilateral supratentorial illnesses [5-7]. Although our study confirmed this relationship, it differed from these reports in that the amount of lateral brain displacement and the degree of diminution of consciousness did not correlate. This made us believe that in patients with CSDH, impairment of consciousness occurs after brain displacement exceeds a threshold level, in contrast to patients with acute lesions in whom there seems to be a linear correlation between the amount of shift and degree of mental change. It is probable that in patients with CSDH, compression on brain tissue is tolerated until a threshold level is reached; impairment of consciousness happens only after this level is exceeded. Inao et al [3], in their group of patients with CSDH, defined a threshold level for mental change to occur rather than grading the degree of loss of consciousness. In patients with mental change, they found an SP shift of 11.6 ± 3.0 mm and a PG shift of

Table 2
Relation between preoperative midline brain shift at SP and PG and preoperative level of consciousness

	No. of patients	Preoperative shift (mean ± SD, mm)	
		SP ($P = .028$)	PG ($P = .05$)
Preoperative GCS 4-14	28	12.71 ± 5.17	7.46 ± 3,49
Preoperative GCS 15	17	9.24 ± 4.67	5.35 ± 3,24

P value was calculated by Student t test.

Table 3
Relation between the degree of preoperative SP shift and postoperative level of consciousness

	Preoperative SP (n)		Total (n)
	<10 mm	≥10 mm	
Postoperative GCS 4-14	3	2	5
Postoperative GCS 15	2	21	23
Total (n)	5	23	28

n indicates number of patients. $P = .027$; $\chi 2$ (Fischer exact test).

7.9 ± 1.7 mm. In our series, patients with diminished consciousness showed similar SP and PG shifts (SP shift, 12.7 ± 5.2 mm; PG shift, 7.4 ± 3.5 mm). They also reported that in 73% (11/15) of patients who had mental change, SP shift was 10 mm or higher. This ratio was 82% (23/28) in our series. Based on the data of Inao et al and our study, it seems likely that an SP shift of 10 to 12 mm is the threshold level for mental change to occur in patients with CSDH. The absence of a linear correlation between the amount of shift and degree of mental change in these two studies may be attributed to the chronic character of the lesions. Indeed, Reich et al [4], in their report demonstrating the relation between clinical signs and brain herniation with supratentorial masses by measurements of midsagittal MRI, confirmed that in chronic cases clinical and MRI findings showed a lesser correlation, whereas in acute illnesses MRI changes anticipated clinical signs of brain herniation.

Regarding the relation between midline brain shift and mental change, Ropper [5] found that PG shift was the most consistent distortion of the brain causing impaired consciousness. Inao et al [3] and Ross et al [7] found that both SP and PG shifts showed significant reverse correlation with the level of consciousness in the preoperative period; whereas in our series, the difference between SP shifts of alert and unconscious patients was statistically significant, and the difference between PG shifts was at the limit of statistical significance. It is probable that both PG and SP shifts correlate well, although we found a higher correlation of SP shift than PG shift with the level of consciousness.

The relation between midline brain shift and restoration of consciousness has been studied before in acute intracranial illnesses [5,7]. Ropper [5] has suggested that when pineal shift was appropriate to the observed depression of consciousness, recovery of consciousness after evacuation of an acute unilateral hemispheric mass lesion could be predicted. On the contrary, if the shift caused by an acute mass was not sufficient to explain a poor level of consciousness, then evacuation of that lesion was unlikely to restore consciousness. They have prospectively confirmed this hypothesis in 6 patients with hemorrhages that were evacuated immediately [5]. Ross et al [7] have evaluated the relation between midline brain shift and restoration of consciousness in the late postoperative period in 46 patients with acute intracranial hemorrhage. They have found that septal shift was significantly larger in patients with a poor long-term outcome. In their series, all 5 patients with septal shifts greater than 15 mm had a poor outcome. However, the study of Ross et al focused on the relation between midline brain shift and overall prognosis at 3 months after operation; it did not have value in the decision on whether an acute unilateral hemorrhage is the direct cause of diminished consciousness and therefore merits surgical evacuation. The change in patient's level of consciousness before and 3 months after operation cannot be attributed to the evacuation of hematoma; various factors such as the patient's age, type and location of the lesion, and complicating pulmonary or vascular diseases influence long-term prognosis. Havenbergh et al [2], in their study correlating size of the hematoma and midline shift on preoperative CT with outcome at the time of discharge in patients with CSDH, have found that these parameters did not have significant influence on outcome. However, overall outcome in the late postoperative period was studied in this article, which did not allow determination of the influence of operation on the level of consciousness of patients.

There is contradiction between the findings of Ropper [5] and Ross et al [7] regarding the ability of midline brain shift to predict outcome in patients with acute lesions. While Ropper reported that patients with increased pineal shifts were expected to have good outcome (benefit from operation and become alert), Ross et al reported that patients with increased septal shifts were expected to have poor long-term outcome. Our study constitutes the first report documenting the relation between midline brain shift and restoration of consciousness in patients with CSDH. We found that in patients who had complete restoration of consciousness, preoperative SP shifts (13.65 ± 3.45) were higher than those of patients who did not become alert after operation (8.40 ± 9.32), although this difference did not reach statistical significance (P = .147). However, those patients who had a preoperative SP shift of less than 10 mm had a significantly lesser chance to become alert after operation when compared with those patients who had a preoperative SP shift of 10 mm or more (P = .027) (Table 3). Our findings in patients with CSDH favor those of Ropper in that patients with increased midline brain shift have higher chance for restoration of consciousness. With reference to these findings and discussion about the threshold level for mental change to occur, we conclude that it is less likely for patients with SP shifts smaller than 10 mm to have complete restoration of consciousness after operation, whereas patients with SP shifts equal to or greater than 10 mm have increased likelihood of becoming alert after operation. On the other hand, in patients with acute intracranial hemorrhage, high SP shifts are usually accompanied by low GCS scores; therefore, poor outcome in these patients, as reported by Ross et al, should be attributed not only to direct compression of hemorrhage but also to diffuse damage or injury to critical midline structures.

5. Conclusion

This study shows that the patients who have a preoperative SP shift of less than 10 mm have a significantly lesser chance of becoming alert after operation when compared with those patients who have a preoperative SP shift of 10 mm or more. Preoperative SP shift may be used as a factor to predict restoration of consciousness in patients with CSDH. If patients with impaired consciousness and CSDH do not have sufficient SP shifts (especially below 10 mm) to explain mental change, accompanying diseases should be investigated.

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Commentary

The authors present an evaluation of the relationship between preoperative and postoperative level of consciousness and midline shift in patients with chronic subdural hematoma. They have found that preoperative level of consciousness correlates loosely with midline shift. More interestingly, and with statistical significance, they have found that, in patients with decreased level of consciousness at presentation, a small shift is predictive of a lower chance of recovery after operation.

Stated differently, a small anatomic defect makes it more likely that there is a separate cause of the alteration of consciousness. Surgical evacuation of a small CSDH may still provide the best available chance of recovery in a particular patient after evaluation, but the likelihood of benefit may be small. This prognostic knowledge can be very useful in both the decision making regarding intervention and in the counseling of patient's families regarding the realistic probabilities of outcome and the risk/benefit ratio of surgical intervention.

The authors are to be congratulated for this useful contribution.

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