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The Fate of Traumatic Subdural Hygroma in Serial Computed Tomographic Scans

We reviewed serial computed tomographic (CT) scans of 58 patients with traumatic subdural hygroma (SDG) to investigate its natural history. All were reevaluated with a special reference to the size and density of SDG. Thirty-four patients (58.6%) were managed conservatively and 24 patients (41.4%) underwent surgery. The lesion was described as remained, reduced, resolved, enlarged and changed. Means of interval from injury to diagnosis and any changes in CT were calculated. SDGs were resolved in 12 (20.7%), reduced in 15 (25.9%), remained in 10 (17.2%), enlarged in 2 (3.4%), and changed into chronic subdural hematoma (CSDH) in 19 patients (32.8%). SDG was diagnosed at 11.6 days after the injury. It was enlarged at 25.5 days, remained at 46.0 days, reduced at 59.3 days, resolved at 107.5 days, and changed into CSDH at 101.5 days in average. SDGs were developed as delayed lesions, and changed sequentially. They enlarged for a while, then reduced in size. The final path of a SDG was either resolution or CSDH formation. Nearly half of SDGs was resolved or reduced within three months, however, 61.3% of unresolved or unreduced SDG became iso- or hyperdense CSDH. These results suggest that the unresolved SDG is the precursor of CSDH.

Key Words : *Lymphangioma, Cystic; Hematoma Subdural; Tomography, X-ray Computed; Head Injuries*

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INTRODUCTION

Traumatic subdural hygroma (SDG) is an accumulation in the subdural space of cerebrospinal fluid (CSF), frequently with modified composition (1). It is a common posttraumatic mass lesion (1-7). However, the clinical significance of this lesion remains obscure (1, 5, 7-11) and the natural history of traumatic SDG is not well-known. Kopp (12) reported that more than 85% of SDG was resolved within 3 months, while Ohno et al. (4) reported that more than half of SDG became chronic subdural hematoma (CSDH). We tried to investigate the natural history of SDG by serial computerized tomographic (CT) scans.

MATERIALS AND METHODS

From 1988 to 1994, we treated 116 patients with traumatic SDG. In each of the 116 cases of SDG, the lesion was absent on the initial CT scans and detected on repeated CT scans. In 42 patients, repeated CT scans were not done because the SDG was small and there were no relevant symptoms. We excluded 11 patients who expired within four weeks. In 13 patients, the follow-up period was less than four weeks. Two patients were lost to follow-up. We selected 58 patients in whom at least two repeated CT scans (except immediate postoperative CT) were performed and the follow-up period was longer than four weeks. All were collected and reevaluated by a neuroradiologist with a special reference to the size and density of SDG. The changes in the repeated CT scans were described as remained (no gross change in size and density), reduced (the size was decreased), resolved (no visible hygroma), enlarged (the size was increased), and changed (the density became iso- or hyperdense, being CSDH as in Fig. 1). They were divided into surgical and conservative groups. Surgery was performed only when the lesion was enlarged in serial CT scans. Thirty-four patients (58.6%) were managed conservatively and 24 patients (41.4%) underwent surgery. Five patients in the conservative group underwent surgery due to subsequent development of CSDH.

Two hundred and fifty-four CT scans (4.4 CT scans

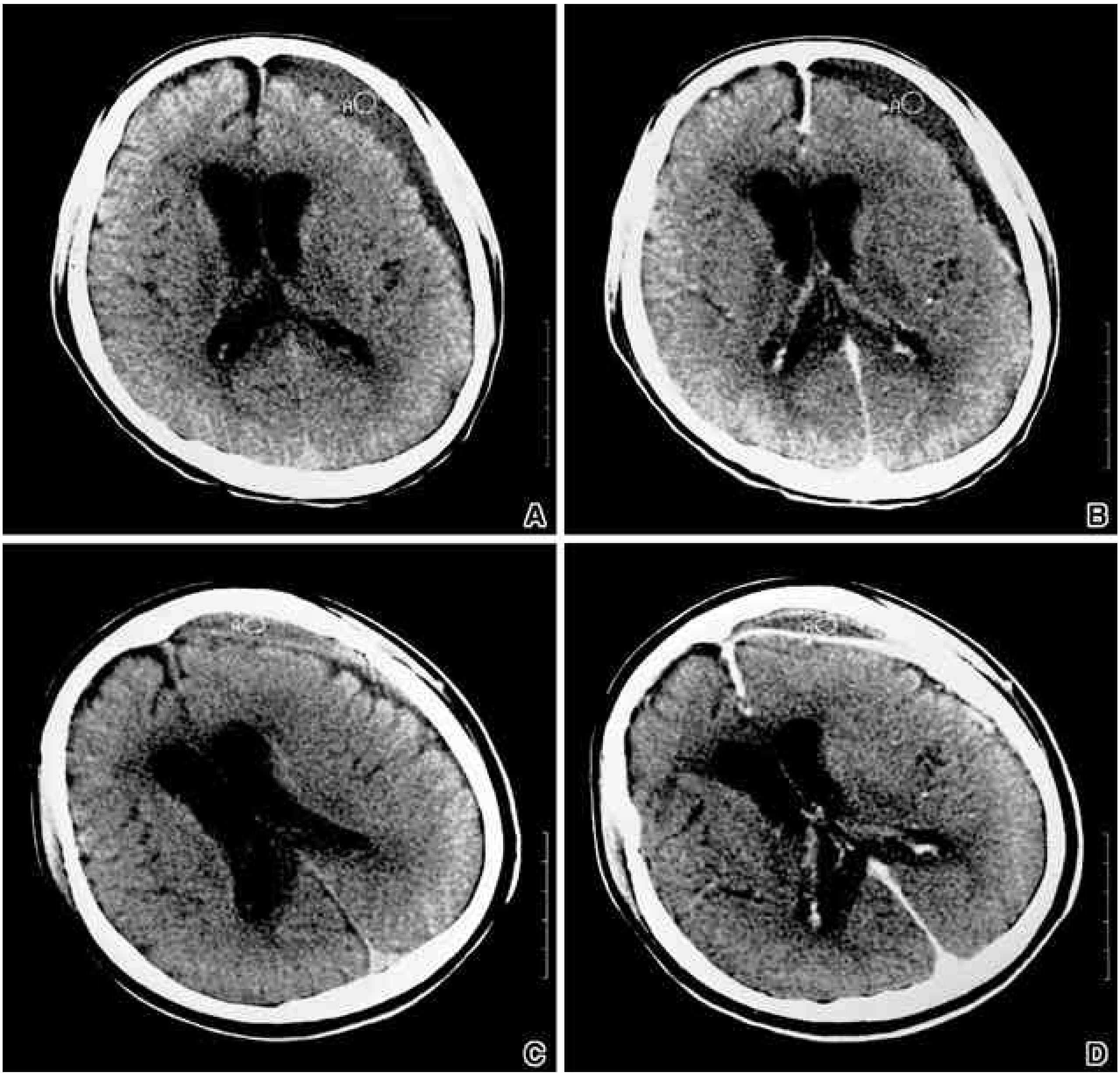

Fig. 1. Pre (**A, C**)- and post (**B, D**)-enhanced CT scans of CSDH from SDG in a 33 year old male patient on Day 117 (**A, B**) and Day 397 (**C, D**). The density of the lesion is 25.4 (**A, B**) and 39.0 (**C, D**) Hounsfield Units in pre-enhanced CT scans.

per case in average) were re-evaluated and mean values of interval from injury to diagnosis and any changes in CT were calculated in both surgical and conservative groups. When SDG was resolved or changed into CSDH, findings of further CT scans were not included. The mean follow-up period was 89.8 days (range 28 to 261 days). The statistical tests used were chi-square test, Fisher's test, Student's t test and regression analysis. For regression analysis, Glasgow Outcome Scale (13) was converted into a numeric scale such as 5 for good recovery, 1 for death. Radiological outcome was also converted into a numeric scale such as 4 for changed, 3 for enlarged, 2 for remained, 1 for reduced and 0 for resolved for regression analysis.

RESULTS

Clinical features

SDGs commonly occurred after 50 years (50.0%) and before 10 years of age (17.2%) (Table 1). The mean age of the surgical group was 39.8 years, and that of the conservative group was 48.7 years. They ranged from 1 to 83 years (average, 45 years). Male to female ratio was 2.8:1 in the conservative group and 5:1 in the surgical

Table 1. Clinical characteristics of surgical and conservative groups

Features	Surgical	Conservative	Total (%)
Age (years)			
0-10	3	7	10 (17.2)
11-20	1	1	2 (3.4)
21-30	2	2	4 (6.9)
31-40	6	1	7 (12.1)
41-50	4	2	6 (10.3)
51-60	8	3	11 (19.0)
Over 60	10	8	18 (31.0)
Causes of injury			
Pass TA	8	21	29 (50.0)
Ped TA	14	12	26 (44.8)
Others	2	1	3 (5.2)
GCS on admission			
3- 8	17	11	28 (48.3)
9-12	5	7	12 (20.7)
13-15	2	16	18 (31.0)
Follow-up period (weeks)			
4- 8	9	8	17 (29.3)
8-12	6	12	18 (31.0)
12-16	2	5	7 (12.1)
16-20	3	4	7 (12.1)
Over 20	4	5	9 (15.5)
Outcome			
GR	3	12	15 (25.9)
MD	4	14	18 (31.0)
SD	12	3	15 (25.9)
VS	4	1	5 (8.6)
D	1	4	5 (8.6)

Pass TA, passenger's traffic accident; Ped TA, pedestrian traffic accidents; GCS, Glasgow Coma Scale score; GR, good recovery; MD, moderate disability; SD, severe disability; VS, vegetative state; D, death

group. Most of the injuries (94.8%) were attributed to traffic injuries. The mean Glasgow Coma Score (GCS) of the surgical group was 6.6 (SD; 3.1), and that of the conservative group was 10.7 (SD; 4.0). Surgery was more frequently performed when the GCS was 3-8. Forty-seven cases (81.0%) of SDG were diagnosed later than 3 days after the injury. They ranged from 1 to 40 days after injury. Mean follow-up period was 87.8 days in the surgical group and 91.2 days in the conservative group. Mean follow-up period of the former was shorter than the latter, however, this difference was not statistically significant (Student t test, $p>0.1$).

Table 2. Radiological outcome of surgical and conservative groups

Outcome	Surgical	Conservative	Total (%)
Resolved	4	8	12 (20.7)
Reduced	7	8	15 (25.9)
Remained	6	4	10 (17.2)
Enlarged	1	1	2 (3.4)
Changed	6	13	19 (32.8)

Clinical outcome at discharge was favorable (good recovery and moderate disability) in 33 (56.9%), unfavorable (severe disability and vegetative state) in 20 (34.5%), and death in 5 (8.6%). The outcome was closely related to the GCS on admission (by regression analysis r=0.3518, $p<0.02$). The outcome of the conservative group was better than that of the surgical group, since the mean GCS of the surgical group was lower than that of the conservative group.

Features of serial CT scans

In the surgical group, SDG was resolved in 4 (16.7%), reduced in 7 (29.2%), remained in 6 (25.0%), enlarged in 1 (4.2%), and changed into CSDH in 6 patients (25.0%) (Table 2). In the conservative group, SDG was resolved in 8 (23.5%), reduced in 8 (23.5%), remained in 4 (11.8%), enlarged in 1 (2.9%), and changed into CSDH in 13 patients (38.2%). Overall, mean follow-up period was 89.8 days. SDG was resolved in 12 (20.7%), reduced in 15 (25.9%), remained in 10 (17.2%), enlarged in 2 (3.4%), and changed into CSDH in 19 patients (32.8%). In 11 of 27 cases (40.7%) with reduced or resolved SDGs, there was ventricular enlargement or hydrocephalic change (Fig. 2). In 5 of 12 cases (41.7%) with enlarged or remained SDGs, atrophy or cerebromalacia was noticed (Fig. 3). Although the resolved or changed SDG was more common in the conservative group, the radiological outcome did not differ significantly (Fisher's test, $p>0.1$).

The radiological outcome differed from the clinical outcome of SDG (Table 3). The favorable outcome in the

Table 3. Radiological outcome and clinical outcome

GOS	Resolved	Reduced	Remained	Enlarged	Changed
GR	5	4	3	1	2
MD	3	2	0	0	13
SD	2	7	4	1	1
VS	1	0	1	0	3
D	1	2	2	0	0

GOS, Glasgow Outcome Scale; GR, good recovery; MD, moderate disability; SD, severe disability; VS, vegetative state; D, death

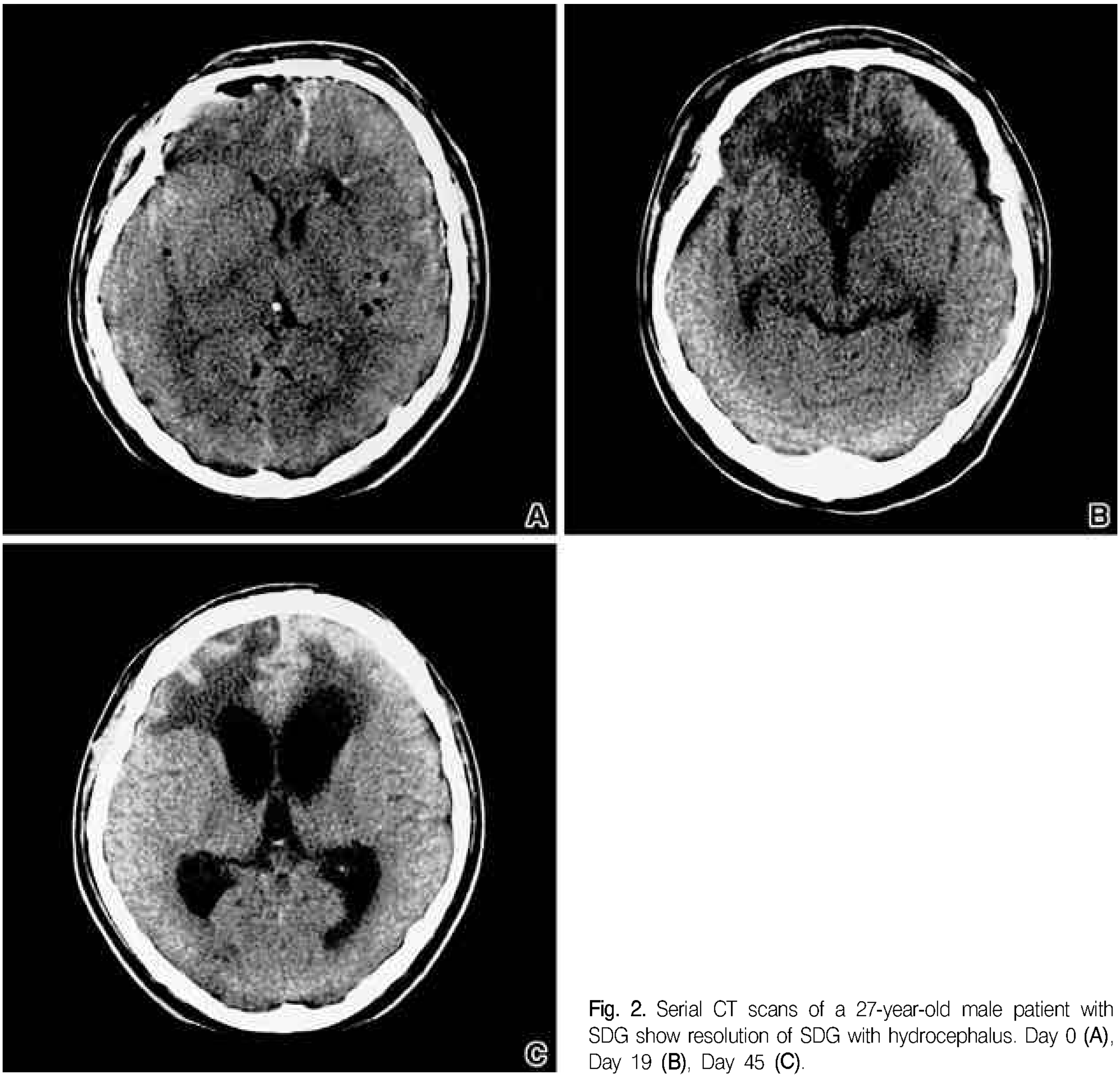

Fig. 2. Serial CT scans of a 27-year-old male patient with SDG show resolution of SDG with hydrocephalus. Day 0 (**A**), Day 19 (**B**), Day 45 (**C**).

enlarged or changed group was 76.2%, while it was 51.9% in the resolved or reduced group. Regression analysis was also not significant (r=0.1256, $p>0.1$).

In the surgical group, SDG was diagnosed at 12.8 days after the injury. It was enlarged at 31.0 days, remained at 48.7 days, reduced at 73.8 days, resolved at 110.0 days, and changed into CSDH at 105.8 days in average (Table 4). In the conservative group, SDG was diagnosed at 14.2 days after injury. It was enlarged at 27.2 days, remained at 40.3 days, reduced at 63.2 days, resolved at 114.3 days, and changed into CSDH at 91.4 days in average. Overall, SDG was diagnosed at 13.6 days after injury. It was enlarged at 29.5 days, remained at 45.8 days, reduced at 68.7 days, resolved at 113.0 days, and changed into CSDH at 101.5 days in average. There were no significant differences in the mean periods between surgical and conservative groups (Student t test, $p>0.1$)

DISCUSSION

The most interesting finding of this study was the rate of subsequent CSDH formation. SDGs were changed into iso- or hyperdense CSDH in 33%. CSDH from SDG is not uncommon, but the rate of subsequent CSDH formation ranged from 4 to 58% (3, 4, 7, 12, 14-18). Such varying incidence may be derived from the differences in length of observation, rate of surgery, and diagnostic criteria of CSDH. The interval from injury to CSDH

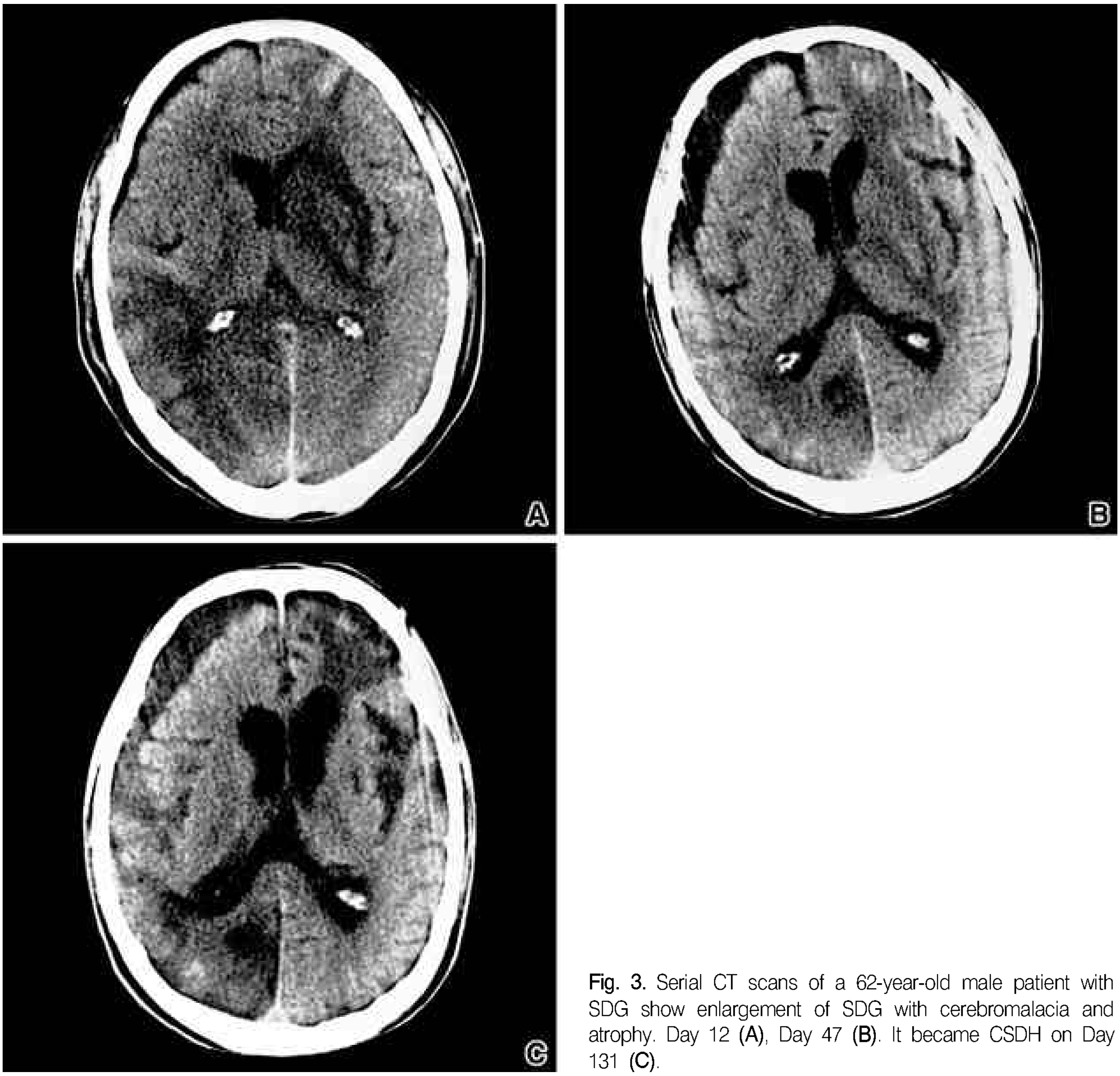

Fig. 3. Serial CT scans of a 62-year-old male patient with SDG show enlargement of SDG with cerebromalacia and atrophy. Day 12 **(A)**, Day 47 **(B)**. It became CSDH on Day 131 **(C)**.

formation was reported as about two months (4, 16, 18-20). The rate of surgery ranges from 40% to 100% (1, 2, 7, 21, 22). If surgery was performed or follow-up was discontinued before transformation, the incidence would be low. Park et al. (18) suggested that paucity of papers dealing with CSDHs from SDGs in the Western countries was derived from their tendency of surgical treatment. Distinguishing between a SDG and CSDH is a controversial issue. If the fluid is extremely bloody, the lesion is called a subdural hematoma; if the fluid is clear and xanthochromic or only slightly blood-tinged, it is often referred to as a SDG (9). The attenuation coefficient (density) in CT is not reliable to differentiate from hypodense CSDH. The density of cerebrospinal fluid (CSF) with 7 g/100 mL protein is 12 EMI units (23), while densities of hypodense CSDHs were found to range from 4 to 14 EMI units (24). The subdural fluid within a SDG is frequently a mixture of blood and CSF (9), and unresolved SDGs frequently become CSDHs (3, 4, 7, 12, 14-18, 20). In this study, we diagnosed the lesion as CSDH when the density became iso- or slightly hyperdense. If we include hypodense CSDH, the rate of subsequent CSDH formation would be higher. Nearly half of SDGs was resolved or reduced within about three months, but a one-third of SDGs was changed into iso- or hyperdense CSDH in our study. Although this study was a retrospective study, 61.3% of unresolved or unreduced SDG became iso- or hyperdense CSDH.

The origin of SDG was a matter of debate (5-7). Now, we believe that separation of the dura-arachnoid interface

Table 4. Mean periods of changes in serial CT scans (days)

Groups	Diagnosed	Resolved	Reduced	Remained	Enlarged	Changed
Surgical						
Average	12.8	110.0	73.8	48.7	31.0	105.8
SD	11.0	70.3	45.2	28.6	18.5	58.5
N*	24	4	14	19	24	7
Conservative						
Average	14.2	114.3	63.2	40.3	27.2	91.4
SD	12.3	49.2	32.6	14.5	13.8	52.3
N*	34	8	11	10	8	13
Total						
Average	13.6	113.0	68.7	45.8	29.5	101.5
SD	11.8	56.5	40.0	25.0	17.0	56.6
N*	58	12	25	29	32	19

*, number of re-evaluated CT scans; SD, standard deviation

is the initiating factor and a sufficient potential subdural space is an important precondition of SDG. We have reported the proposed pathogenesis of SDG elsewhere (7). To explain the mechanism of CSDH formation from SDG, we repeat here, briefly. The so-called subdural space is not present in normal condition, but a minute trauma could separate the dura-arachnoid interface, the so-called dural border cell layer (25-27). Not only head injury, but also any cranial operations may separate this interface. Koizumi et al. (28) reported the incidence of postoperative subdural fluid collections as high as 17% in 1,013 cranial operations for nontraumatic lesions. Any pathologic condition inducing cleavage of tissue within the dural border cell layer can induce proliferation of dural border cells with production of neomembrane (25-27). Hasegawa et al. (29) detected the subdural neomembrane in SDG by magnetic resonance imaging (MRI) with gadolinium enhancement. We also found such phenomenon as in Fig. 4. Most SDG will disappear when brain expansion or fluid absorption exceeds effusion (7). Once neomembrane is formed, hyperpermeable capillaries will follow with time (25). If the absorption takes time, hemorrhage into the subdural fluid would occur either by bleeding from neomembrane or tearing of bridge veins. We expect that most CSDH will be produced by this mechanism. Nearly half of patients with CSDH has no history of head injury (6), and CSDHs are seen only uncommonly following severe brain injury (30). These

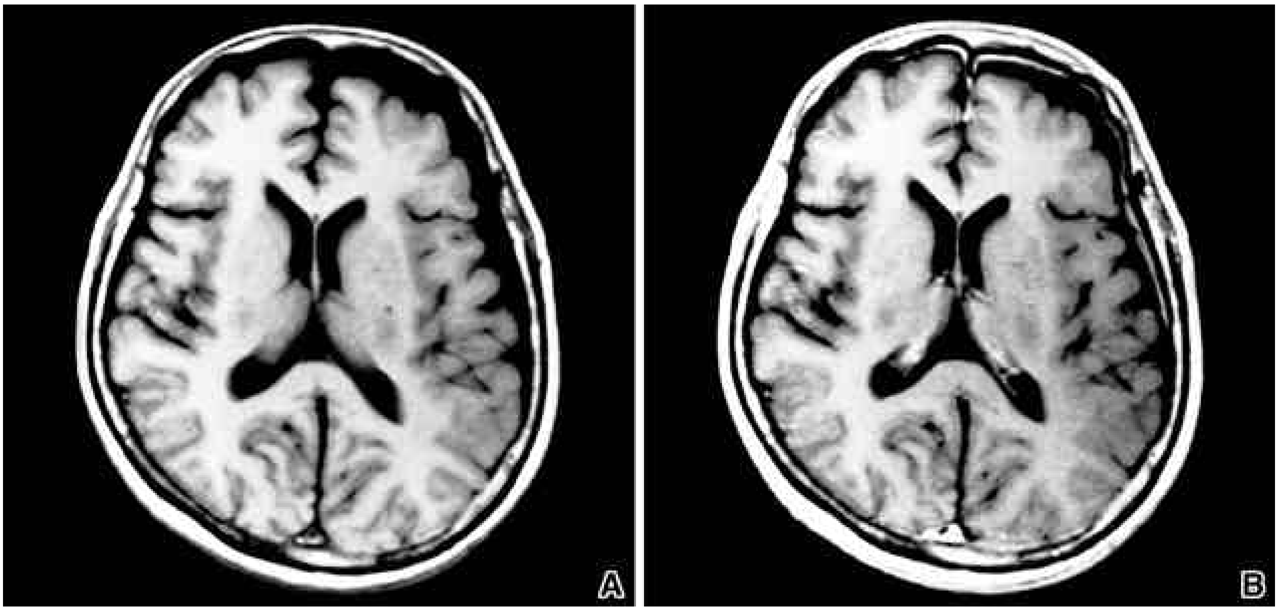

Fig. 4. Pre (A)- and post (B)-enhanced T1-weighted MRI of a 72-year-old female on Day 13 show definite dural enhancement by Gd-DTPA.

facts imply that the injury itself is trivial or minor. Such a trivial injury, however, can produce SDG, the precursor of CSDH.

SDG was diagnosed at 13.6 days after injury. It was enlarged at 29.5 days, remained at 45.8 days, reduced at 68.7 days, resolved at 113.0 days, and changed into CSDH at 101.5 days in average. These results implied that SDGs developed as delayed lesions, then sequentially changed. They continued to be enlarged for a while, then reduced in size. The final path of a SDG was either resolution or CSDH formation. Since we selected only patients in whom at least two repeated CT scans were performed except immediate postoperative CT and the follow-up period was longer than four weeks, the mean period of each radiological change of all SDGs would be shorter than our results. Ohno et al. (4) reported that mean interval from injury to transformation was 68±34 days. Kopp (20) also reported that mean interval was 63 days (range from 32 to 120 days) in 24 CSDHs from SDGs. Mean interval of our study was longer than those studies. This discrepancy may result from different diagnostic criteria. In this study, we diagnosed the lesion as CSDH when the density became iso- or slightly hyperdense. The density of CSDH from SDG tended to change sequentially from hypodensity to iso- or slightly hyperdensity (12, 15).

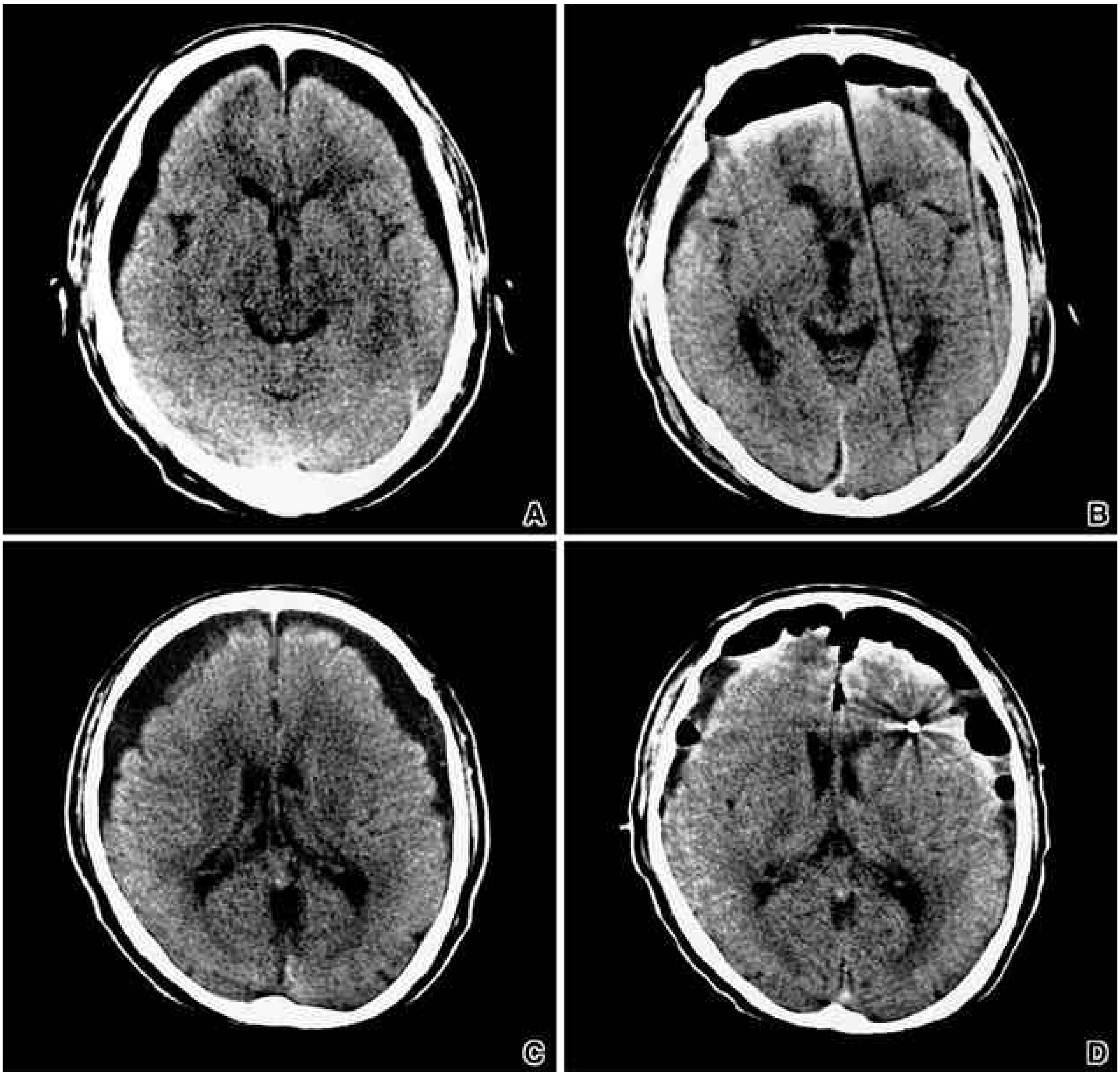

Fig. 5. Pre **(A, C)**- and post **(B, D)**-operative (burr-hole drainage) CT scans of a 76 years old male **(A, B)** and a 65 years old male **(C, D)** patients with SDG show air instead of fluid in the subdural space. The size was not reduced in both cases.

Another interesting finding of this study was the role of surgery. Although the rate of CSDH formation from unresolved or unreduced SDG was relatively low in the surgical group (46% vs 72%), the number of resolved or reduced SDGs in surgical group did not significantly differ from the conservative group. Not only number but also mean interval from injury to resolution or reduction did not differ from the conservative group. This result implied that surgery did not seem to be effective in resolving SDG. The majority of patients with SDG do not show a mass effect. SDG is a passive space-filling lesion. When there is a sufficient subdural space, created by atrophy or cerebromalacia, SDG will be enlarged. When there is ventricular enlargement or hydrocephalic change, SDG will be reduced. Such phenomena were observed over 40% of our cases. Persistence of the subdural space filled with either air or fluid is quite common (1, 21, 31) after burr hole drainage even in cases with a subdural drain (Fig. 5). If the brain remained shrunken or absorption of the subdural fluid was poor, the subdural space tends to persist.

Finally, the radiological outcome of SDG did not correlate with the clinical outcome. The clinical outcome was closely related to GCS on admission. Drainage of SDG did not result in clinical improvement in patients with severe established deficits (1, 21). Mortality of SDG has been reported to range from 12 to 28% (6). However, outcome is not related to the SDG itself, but closely related to the severity of primary head injury (7).

SDGs were developed as delayed lesions, then they changed sequentially. They continued to be enlarged for a while, then reduced in size. The final path of a SDG was either resolution or CSDH formation. Nearly half of SDGs was resolved or reduced within about three months, but 61.3% of unresolved or unreduced SDG became iso- or hyperdense CSDH. These results strongly suggest that SDG is the precursor of CSDH. The clinical outcome was closely related to initial GCS, and radiological outcome of SDG did not correlate with the clinical outcome. Surgery does not seem to be effective in resolving SDG.

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