

Original Article

## Incidence and Prognostic Significance of Postoperative Complications Demonstrated on CT after Brain Tumor Removal

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**Abstract:** We surveyed the computed tomographic (CT) findings in 273 patients who had undergone 301 craniotomies for brain tumors to determine the incidence and clinical outcome of the postoperative complications demonstrated on CT. The frequencies of medium-sized or large postoperative lesions were as follows: intracerebral hemorrhage, 11% of 301 operations; subdural fluid collection, 8%; brain edema, 6%; extradural hemorrhage, 4%; cerebral infarction, 3%; ventricular enlargement, 3%; intraventricular hemorrhage, 2%; chronic subdural hematoma, 1%; porencephalic cyst, 0.7%; tension pneumocephalus, 0.7%. In association with these complications, poor outcomes (deaths) developed with the following frequencies: intracerebral hemorrhage including an association with other types of hemorrhage, 4% (deaths, 2%) of 301 operations; cerebral infarction, 1% (deaths, 0.7%); brain edema, 0.7% (deaths, 0.7%); simple intraventricular hemorrhage, 0.3% (no deaths); tension pneumocephalus, 0.3% (no deaths). From these results, we conclude that medium-sized or large intracerebral hemorrhage, massive cerebral infarction and edema have a grave clinical significance in the postoperative course of patients with brain tumors.

**Key words:** Postoperative complication, Brain tumor, Computed tomography

### INTRODUCTION

A variety of complications after brain tumor removal has been reported and some of them are known to be serious and often fatal. Computed tomographic (CT) studies have made it possible to evaluate most of these complications in the early postoperative period.

The purpose of this report, based on a survey of clinical notes and postoperative CT findings, is to review the incidence and outcome of the postoperative complications which were demonstrated by CT in 273 patients who had undergone 301 cranio-

tomies for brain tumors and to discuss the prognostic significance of these complications.

### PATIENTS AND METHODS

Between August 1976 and March 1984 in Gunma University Hospital and between April 1984 and April 1986 in Yamanashi Medical College Hospital, pre- and postoperative CT scans were obtained for 301 craniotomies for brain tumors in 273 patients. Twenty-four patients were operated upon more than once. There were 128 men and 145 women, ranging in age from 2 to 79 years.

Postoperative CT scans were first performed within a week of surgery in most

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patients and repeated when necessary. Extradural and subdural hemorrhages were divided into small (maximum thickness < 1 cm), medium-sized (1–2 cm), and large (> 2 cm)<sup>4)</sup>. Intracerebral hemorrhages, including bleeding at the site where the tumor had been removed, were classified as small (maximum diameter < 3 cm), medium-sized (3–5 cm), and large (> 5 cm)<sup>2)</sup>. Subdural fluid collections were defined as low density areas in the subdural space, and were divided into small (maximum thickness < 1 cm) and large (> 1 cm)<sup>7)</sup>. Postoperative chronic subdural hematomas were diagnosed when, in comparison with the initial CT scan, an increase of volume and/or change of density in the subdural space were seen. Large intraventricular hemorrhages were defined as cast-like clots in more than one lateral

ventricle. Large subarachnoid hemorrhages met the criteria corresponding to Group 3 of Fisher, Kistler and Davis<sup>1)</sup>. Ventricular enlargement was diagnosed when the frontal cerebroventricular index<sup>5)</sup> was 35% or more, or when there was an increase in the index if ventricular dilatation had been present preoperatively. Tension pneumocephalus was defined as an intracranial air collection with increased intracranial pressure. Clinical outcomes associated with the complications were evaluated according to the Glasgow Outcome Scale<sup>11)</sup> at the time of discharge from the hospital. Poor outcome was defined as severe disability, persistent vegetative state and death.

## RESULTS

The postoperative complications which

Table 1. Postoperative complications and poor outcomes after 301 craniotomies for the removal of brain tumors

Complication	Number of patients affected	Size of the involved area			Operations <sup>a</sup>	Number of patients with poor outcome		
		S	M	L		SD	PVS	D
Extradural hemorrhage	70	59	9	2	5	0	1 <sup>f</sup>	0
Subdural hemorrhage (acute, subacute)	5	5	0	0	0	0	0	0
Intracerebral hemorrhage <sup>b</sup>	89	55	25	8	6	3	1	7
Intraventricular hemorrhage	18	13		5	1	2 <sup>g</sup>	1	2 <sup>g</sup>
Subarachnoid hemorrhage	6	4		2	0	1 <sup>g</sup>	0	1 <sup>g</sup>
Subdural fluid collection	66	42		24	1 <sup>c</sup>	0	0	0
Chronic subdural hematoma	3		3		2	0	0	0
Cerebral infarction	10		10		0	2	0	2
Brain edema	19		19		0	0	0	2
Porencephalic cyst	2		2		0	0	0	0
Air collection	95	93		2 <sup>c</sup>	1	1	0	0
Ventricular enlargement	15	5		10 <sup>d</sup>	10	0	0	0

Abbreviations: S, small; M, medium-sized; L, large; SD, severe disability; PVS, persistent vegetative state; D, dead.

<sup>a</sup> Number of operations for treatment of the complications.

<sup>b</sup> Bleeding at the operative site is included.

<sup>c</sup> Large air collection means tension pneumocephalus.

<sup>d</sup> Large ventricular enlargement means a case requiring a shunt operation.

<sup>e</sup> One patient with subdural fluid collection was operated at the stage of chronic subdural hematoma.

<sup>f</sup> This patient had large extradural and medium-sized intracerebral hemorrhages.

<sup>g</sup> Four patients with large intraventricular hemorrhages and two patients with large subarachnoid hemorrhages also had medium-sized or large intracerebral hemorrhages.

were demonstrated on CT scans are summarized in Table 1. No brain abscesses or extra- or subdural empyemas were demonstrated in this series. The histological diagnoses of the 301 brain tumors are shown in Table 2.

Table 2. Histological diagnoses of the brain tumors

Meningioma	78
Malignant astrocytoma, Glioblastoma	53
Neurinoma	27
Pituitary adenoma	24
Craniopharyngioma	19
Low-grade astrocytoma <sup>a</sup>	18
Metastatic tumor	17
Medulloblastoma	16
Oligodendroglioma	7
Hemangioblastoma	6
Ependymoma	5
Teratoma	5
Epidermoid, Dermoid tumor	5
Hamartoma	4
Optic glioma	3
Choroid plexus papilloma	2
Embryocarcinoma	2
Cavernous hemangioma	2
Chondrosarcoma	2
Others	6
Total	301

<sup>a</sup> The category of low-grade astrocytoma includes six cases of cerebellar astrocytoma.

*Extradural hemorrhage.* Eleven postoperative extradural hemorrhages were medium-sized or large (3.7% of 301 operations). Of these 11 hemorrhages, five were evacuated. Three of the five were associated with an acute clinical course and two with a subacute course. Two patients had a malignant astrocytoma or glioblastoma, one had a metastatic tumor, one had a pineal embryonal carcinoma and one had a craniopharyngioma.

One patient developed a persistent vegetative state despite the evacuation of an extradural hemorrhage. He had also had a medium-sized intracerebral hemor-

rhage at the operative site. The other patients recovered well.

*Acute or subacute subdural hemorrhage.* We found no postoperative medium-sized or large subdural hemorrhages associated with an acute or subacute clinical course. Five small hemorrhages were found without clinical significance except for one, which later developed into a chronic subdural hematoma.

*Intracerebral hemorrhage.* Thirty-three medium-sized or large intracerebral hemorrhages were found (11.0% of 301 operations). The clinical outcomes of the 33 patients were: good recovery for 20 patients, moderate disability for 2, severe disability for 3, persistent vegetative state for 1 and death for 7.

The outcomes were analyzed in relation to such factors as the size and site of the hemorrhage, the presence of other types of hemorrhage, whether an operation for the postoperative intracerebral hemorrhage was performed, and the histological classification of the tumor (Table 3). A higher death rate was seen in patients who experienced large hemorrhages than in those with medium-sized ones. When the hemorrhages occurred at the site from which the tumor had been removed and were larger than the primary lesion, there was a tendency for a poor outcome. Three of four patients with hemorrhages in the suprasellar region died. In patients with intraventricular, subarachnoid, or large extradural hemorrhages, poor results were found ( $p < 0.005$ ). There was no significant difference with respect to the risk of a clinically poor outcome between patients with and without operations for the postoperative intracerebral hemorrhages. Of 24 patients with transcranial removal of pituitary adenomas, three (12.5%) died.

*Intraventricular hemorrhage.* Large intraventricular hemorrhages were found in

Table 3. Relationship between clinical outcome and postoperative medium or large intracerebral hemorrhages

Clinical outcome Patients (n)	GR 20	MD 2	SD 3	PVS 1	D 7	Total 33	
Size of ICH							
Large	4	0	0	0	3	7	
Medium	16	2	3	1	4	26	
Size of ICH compared with tumor size (28 cases)							
Larger	2	0	1	1	3	7	
Same	3	0	0	0	2	5	
Smaller	11	2	1	0	2	16	
Site of ICH							
Cerebral lobes <sup>a</sup>	17	1	1	0	3	22	
Pineal region	0	0	0	1	0	1	
Suprasellar region	0	0	1	0	3	4	
Cerebellum	2	1	1	0	1	5	
Cerebellopontine angle	1	0	0	0	0	1	
Other types of hemorrhage							
(+)	0	2	1	1	5	9	
(−)	20	0	2	0	2	24	
Operation for ICH							
(+)	4	0	0	0	1	5	
(−)	16	2	3	1	6	28	
Histological classification							
	(Total)						
Pituitary adenoma	(24)	1	0	1	0	3	5
Craniopharyngioma	(19)	1	0	0	0	0	1
Meningioma	(78)	9	1	0	0	2	12
Glioblastoma/Malignant							
astrocytoma	(53)	5	0	0	0	1	6
Low-grade astrocytoma	(18)	1	0	0	0	0	1
Acoustic neurinoma	(27)	2	0	0	0	0	2
Embryonal carcinoma	( 2)	0	0	0	1	0	1
Metastatic tumor	(17)	1	1	0	0	1	3
Oligodendroglioma	( 7)	0	0	1	0	0	1
Ependymoma	( 5)	0	0	1	0	0	1

Abbreviations: ICH, intracerebral hemorrhage; GR, good recovery; MD, moderate disability; SD, severe disability; PVS, persistent vegetative state; D, dead.

<sup>a</sup> I.e., frontal, parietal, temporal, or occipital lobes.

five patients (1.7% of 301 operations). In four of the five, the hemorrhages were associated with major intracerebral or subarachnoid hemorrhages. Two of the four patients had a pituitary adenoma, one had a glioblastoma and one had a metastatic tumor. Their outcomes were: severe disability in two and death in the

other two. Simple massive intraventricular hemorrhages were found in a patient with a cerebellar hemangioblastoma. Despite a continuous ventricular drainage, the outcome was a persistent vegetative state.

*Subarachnoid hemorrhage.* Subarachnoid hemorrhages were demonstrated postoperatively in six patients. Two patients

(0.7% of 301 operations) with a pituitary adenoma had thick subarachnoid hemorrhages associated with other major intracerebral or intraventricular hemorrhages. Their outcomes were severe disability in one patient, and death in the other. Another patient with a small subarachnoid hemorrhage after surgery for a pituitary adenoma had a symptomatic arterial vasospasm a week after the operation resulting in a moderate disability<sup>9)</sup>.

*Subdural fluid collection.* Postoperative subdural fluid collections occurred after 66 of the 301 operations. Of the 66 collections, 24 were large on the first CT scan (8.0% of 301 operations). Sequential CT examinations revealed an increase in the subdural fluid collection in eight patients (2.6%). The maximum thickness was seen about 20 to 30 or more days after surgery. However, only one patient with an ependymoma had distinct clinical symptoms referable to the collection. She was operated on at the stage of chronic subdural hematoma with good recovery. In the other patients with minimal or no clinical symptoms, the collections disappeared or decreased in volume.

*Chronic subdural hematoma.* Three patients had postoperative chronic subdural hematomas (1.0% of 301 operations). One had a cerebellar ependymoma, one had an acoustic neurinoma and one had a pineal teratoma. After tumor removal, two of the three patients had bilateral subdural fluid collections and one an acute thin subdural hemorrhage on the early postoperative CT scans. Chronic subdural hematomas, unilateral in two patients and bilateral in one, were diagnosed on CT scans 24, 62 and 65 days after surgery, respectively. Two of them had symptoms of increased intracranial pressure and the hematomas were evacuated with good recovery. One patient had no clear symptoms

despite bilateral thick subdural hematomas, and was therefore treated conservatively with good outcome.

*Cerebral infarction.* Ten patients had postoperative cerebral infarctions (3.3% of 301 operations). In three of the ten, the intracranial internal carotid artery was occluded, and their outcomes were death in two patients and severe disability in one. Two of them had had craniopharyngiomas and the other one a sphenoid ridge meningioma. In another patient with a sphenoid ridge meningioma, the trunk of the middle cerebral artery was occluded resulting in a severe disability. In one patient with a craniopharyngioma, a branch of the middle cerebral artery was occluded, probably due to embolization, but the patient recovered well. In the other five patients, perforators from the anterior or middle cerebral arteries were occluded. The diagnoses in these five patients were dermoid tumor in the sylvian fissure, hypothalamic hamartoma, hamartoma in the third ventricle, sphenoid ridge meningioma and tuberculum sellae meningioma. Their outcomes with respect to the occlusions were good recovery in four patients and severe disability in one.

*Brain edema.* The distinct enlargement or appearance of brain edema after surgery was found in 19 patients (6.3% of 301 operations). New brain edema was seen in the frontal lobe for five patients (two with pituitary adenomas, one with a craniopharyngioma, one with a lymphoma and one with a meningioma), in the temporal lobe for three (two with meningiomas and one with an epidermoid tumor), in the parietal lobe for one (who had a meningioma), in the bilateral thalami for one (who had a pineal teratoma), and in the cerebellum for one (who had an acoustic neurinoma). Of these 11 patients, one died from massive edema, one died for another

reasons and nine recovered well. Brain edema around the tumor, which had already been seen in a preoperative period, enlarged postoperatively in seven patients whose diagnoses were meningiomas (4 patients), medulloblastoma (1), malignant astrocytoma (1) and low-grade astrocytoma (1). One of the seven patients had a severe disability referable to the preoperative state, and the other six showed good recovery. The last patient had marked sudden edema of the whole brain two weeks after the removal of a metastatic tumor, resulting in death. Marked impairment of liver function was found around the time that the edema occurred.

*Porencephalic cyst.* Porencephalic cyst formation with a mass effect on CT was found at the site of tumor removal in two patients (0.7% of 301 operations). One of them had an embryonal carcinoma, but symptoms of the cyst were minimal. The other patient had a recurrent glioblastoma, and a large cyst was found postoperatively. Although the clinical course was steadily downhill ending in death, it was unclear whether there were symptoms referable to the cyst because of a rapid regrowth of the tumor and concomitant ventricular enlargement.

*Air collection.* Intracranial air collection was found postoperatively in 95 patients, but tension pneumocephalus was demonstrated in only two (0.7% of 301 operations). The two patients had a cerebellar glioma and a medulloblastoma respectively, and were operated on in a sitting position. The outcome of one patient with large bilateral frontal subdural pneumatoceles was severe disability despite depneumatization. She was also thought to have had a cerebral air embolism. The other patient with intraventricular and subdural pneumatoceles was treated conservatively with good recovery.

*Ventricular enlargement.* Postoperative ventricular enlargement was noted in 15 patients, two of whom had an acute onset with ventricular hemorrhage. Eleven of the 15 had no clear ventricular enlargement preoperatively. Ten of the 15 required a ventriculoperitoneal shunt for chronic enlargement (3.3% of 301 operations). Five of the 10 patients had pituitary tumors; four had pituitary adenomas and one had a pituitary metastasis. Two of them had postoperative subarachnoid hemorrhage. Two of the 10 had posterior fossa tumors; one had a cerebellar hemangioblastoma with large postoperative ventricular hemorrhages and the other one had a cerebellar glioma with a postoperative tension pneumocephalus. The other three patients had an astrocytoma, a glioblastoma and a convexity meningioma, respectively. The last two had marked brain edema in the early postoperative period. The final outcomes of the 10 patients were: good recovery in one, moderate disability in two, severe disability in two, and death in five. The poor results were thought to be due mainly to the primary tumors or other severe complications rather than the ventricular enlargement.

#### DISCUSSION

CT scanning has made it possible to study the common postoperative complications experienced by neurosurgical patients<sup>2-4,7,8,10,12</sup>). To our knowledge, there are no reports that have described in detail the incidence and outcome of the postoperative pathological lesions demonstrated on CT in a series of patients treated surgically for tumors, though there is a good monograph which deals with the complications in regard to the individual tumors<sup>6</sup>).

In this series of 301 craniotomies for the removal of brain tumors, the incidences of medium or large postoperative lesions of

clinical significance, were as follows: intracerebral hemorrhage, 11% of 301 operations; subdural fluid collection, 8%; brain edema, 6%; extradural hemorrhage, 4%; cerebral infarction, 3%; ventricular enlargement, 3%; intraventricular hemorrhage, 2%; chronic subdural hematoma 1%; porencephalic cyst, 0.7%; tension pneumocephalus, 0.7%. The subdural fluid collections were of clinical significance only when they grew larger (3%) or changed to chronic subdural hematomas (0.7%). Despite various kinds of treatment, poor outcomes developed in association with these complications as follows: intracerebral hemorrhage, 11 patients (4% of 301 operations); intraventricular hemorrhage, 5 (2%); cerebral infarction, 4 (1%); subarachnoid hemorrhage, 2 (0.7%); brain edema, 2 (0.7%); extradural hemorrhage, 1 (0.3%); tension pneumocephalus, 1 (0.3%). Of these, four intraventricular, two subarachnoid and one extradural hemorrhages were associated with medium-sized or large intracerebral hemorrhage. Further, seven intracerebral hemorrhages (2%), three of which also included intraventricular or subarachnoid hemorrhages, two massive cerebral infarctions (0.7%) and two episodes of massive brain edema (0.7%) caused the patients' deaths. From these results, we think that medium-sized or large intracerebral hemorrhages, cerebral infarctions and brain edema have a grave prognostic significance in the postoperative course of patients who have undergone brain tumor surgery.

As to the intracerebral hemorrhages<sup>2)</sup>, larger hemorrhages, hemorrhages in the suprasellar region, those associated with other types of hemorrhage, and hemorrhages in patients who had pituitary adenomas as the primary lesion all tended to result in a poor outcome or a higher death rate. We suggest that the size and

site of intracerebral hemorrhages and their association with other types of hemorrhage represent important prognostic factors.

With respect to cerebral infarction, occlusion of the main intracranial arteries caused a poor outcome. We had three patients with internal carotid artery involvement and one with middle cerebral artery involvement; all vessels were injured and massive hemorrhage resulted. Two of the vessels were clipped. One carotid artery was clipped with an encircling clip and the other one sutured, but they also occluded eventually. Our experience confirms what Horwitz and Rizzoli stated repeatedly in their monograph<sup>6)</sup>: injury to the major arteries is often the immediate cause of death or poor outcome. Even occlusion of the perforators causes a severe disability. In one patient with a dermoid tumor in the sylvian fissure, many perforators from the middle cerebral artery were embedded in the tumor capsule, but they were eventually sacrificed with a resultant severe hemiparesis and low-density lesion in the basal ganglia.

Massive brain edema caused two deaths in our series. One patient had a large lymphoma in the corpus callosum, and after the tumor was removed totally via the transfrontal approach, severe edema developed in the frontal lobe. In this patient, brain retraction was thought to be the main cause of the edema. The other patient had a marked sudden edema of the whole brain two weeks after the removal of a metastatic tumor. Although marked liver impairment was also present at the time of the appearance of the edema, the exact reason for the sudden edema was not clear even after autopsy. In modern practice with controlled ventilation, mannitol, steroids and microtechniques, brain edema has been largely eliminated<sup>6)</sup>, but we must

still be aware of massive edema as one of the potential grave complications in neurosurgery.

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#### CT 上認識しうる脳腫瘍開頭手術後合併症

——その頻度と臨床結果について——

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脳腫瘍開頭手術後合併症のうちCTで認識しうるものについて、我々の経験例からその頻度と臨床結果を検討した。術前・術後CTの行われた301手術を対象とした。中等大以上の術後病変の頻度は、脳内出血11%、硬膜下液体貯溜8%、脳浮腫6%、硬膜外出血4%、脳梗塞3%、脳室拡大3%、脳室内出血2%、慢性硬膜下血腫1%、孔脳症0.7%、緊張性気脳症0.7%であった。Severe disability, 植物症および死亡からなる臨床結果不良例の頻度は、以下のものであった(括弧内は死亡例の頻度を示す)。すなわち、301手術例中、脳内出血4(2)%、脳梗塞1(0.7)%、脳浮腫0.7(0.7)%、単独脳室内出血0.3(0)%、緊張性気脳症0.3(0)%であった。以上のことから、脳腫瘍患者の開頭手術管理上、とくに脳内出血、脳梗塞、脳浮腫は重篤な結果を来しやすいことを確認した。このうち脳内出血例は、より大きな出血、鞍上部腫瘍(とくに下垂体腺腫)摘出腔内出血、他の頭蓋内出血(くも膜下出血、脳室内出血または硬膜外出血)を合併した出血が臨床結果を不良にしていた。

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