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[Clinical Studies]

Intracerebral Hemorrhage Occurring Remote from the Craniotomy Site

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Abstract

OBJECTIVE: The purpose of this study was to analyze the available clinical data on postoperative intracerebral hemorrhages that occur in locations remote from the sites of craniotomy.

METHODS: The findings of 37 cases of postoperative intracerebral hemorrhages occurring remote from the craniotomy sites were reviewed (5 from our records and 32 from the literature).

RESULTS: Remote postoperative intracerebral hemorrhages presented within the first few hours postoperatively in 78% of the patients and were not related to the types of lesions for which the craniotomies were performed. Supratentorial procedures that produced infratentorial hemorrhages involved operations in the deep sylvian fissure and paraclinoid region in 81% of the patients and hemorrhages in the cerebellar vermis in 67% of the patients. Infratentorial procedures that produced supratentorial hemorrhages were performed with the patient in the sitting position for 87% of the patients. The remote supratentorial hemorrhages that occurred were superficial and lobar in 84% of the patients, as opposed to deep and basal ganglionic, which are classic locations for hypertensive hemorrhages. Remote intracerebral hemorrhages occurring after craniotomies were not associated with hypertension, coagulopathy, cerebrospinal fluid drainage, or underlying occult lesions. These hemorrhages commonly led to significant complications; 5 of 37 patients(14%) were left severely disabled, and 12 of 37 patients (32%) died.

CONCLUSIONS: Remote intracerebral hemorrhage is a rare complication of craniotomy with significant morbidity and mortality. Such hemorrhages likely develop at or soon after surgery, tend to occur preferentially in certain locations, and can be related to the craniotomy site, operative positioning, and nonspecific mechanical factors. They do not seem to be related to hypertension, coagulopathy, cerebrospinal fluid drainage, or underlying pathological abnormalities.

One of the major complications of craniotomy is hemorrhage (6, 12). Postoperative hemorrhages usually occur at the site of the operation but can also occur remotely and may be epidural, subdural, or intracerebral. Although there are few reports in the literature, remote intracerebral hemorrhages cause significant morbidity and mortality, and they are being appreciated more frequently with the increased availability of computed tomographic (CT) and magnetic resonance imaging (MRI) studies. The purpose of this study was to analyze the available data on intracerebral hemorrhages that occur remote from the sites of craniotomy.

PATIENTS AND METHODS

Thirty-seven patients were included in this study. The datA on five patients were obtained from our records. Those five patients had been operated on between April 1994 and February 1995. The data on the remaining 32 patients were obtained from 11 reports in the literature published between 1978 and 1993. The following inclusion criteria were used: 1) patients had undergone“craniotomies,” which we used in the generic sense to include craniectomies or burr holes; 2) patients had suffered intracerebral hemorrhages after the craniotomies, documented on the first postoperative imaging studies or at autopsy; and 3) intracerebral hemorrhages were clearly not contiguous with the operative sites.

There were three types of intracerebral hemorrhage occurring remote from the craniotomy sites that were not included in this study, because they were thought to represent different entities. These were as follows: 1) intracerebral hemorrhage after the removal of arteriovenous malformations, which is a well-described entity caused by cerebrovascular autoregulatory dysfunction/“normal perfusion pressure breakthrough”(21, 24); 2) brain stem hemorrhage after central herniation, i.e., Duret hemorrhages, thought to occur secondary to shear

injury of basilar artery perforators (9, 11); 3) intracerebral hemorrhage that occurred after craniotomy in the setting of acute trauma, which might have reflected late development of a contusion from the initial injury (one study found that 46% of posttraumatic intracerebral hemorrhages manifested themselves >24 h after the initial injury [23]).

The following variables were examined: patient age, gender, craniotomy site, hemorrhage site, history of hypertension, maximum perioperative blood pressure (in some cases, recorded only as “normal” or“increased”), perioperative coagulation parameters, time at which remote hemorrhage was detected (and whether this was an incidental discovery), and long-term complications of the remote hemorrhage.“Perioperative” was defined as the time at which the operation began until 24 hours after the operation ended or until the hemorrhage was discovered, whichever came first. Hemorrhage was considered to have caused a“severe” complication if the patient was left in a dependent state, had major loss of use of a limb because of weakness or incoordination, or sustained a major visual field cut. Complications that did not meet the criteria for “severe” were considered “moderate.”

RESULTS

Case reports

Patient 1

The first patient is a 24-year-old woman who presenteD with panhypopituitarism. A CT scan of the head and an MRI study revealed a calcium-containing suprasellar lesion, eccentric to the left. The patient had no history of hypertension. She underwent a left frontotemporal craniotomy in the supine position for removal of the tumor. While the bone flap was being turned, the patient's blood pressure suddenly fell to zero. The patient was resuscitated, and the incision was closed. After the anesthesia records were reviewed, it was thought that a pulmonary air embolus had likely occurred. The patient developed disseminated intravascular coagulation that began in the operating room and was mostly reversed after 24 to 48 hours. The results of the neurological examination were unchanged from those of the preoperative examination. A postoperative CT scan of the head revealed nothing abnormal.

One week later, all coagulation parameters were normal and the patient was brought back to the operating room. The tumor, which proved to be a craniopharyngioma, was removed via a left frontotemporal craniotomy performed with the patient in the supine position. The intraoperative course was uneventful. Intraoperative blood pressure readings were within the normal range, with a maximum intraoperative systolic blood pressure reading of 150. Postoperatively, hormone replacement therapy was administered and the patient was neurologically intact, except for a transient right upper quadrantanopsia that completely resolved. Postoperative blood pressure readings were mostly in the normal range, with a maximum recorded value of 184/80. MRI performed 1 week postoperatively showed a good resection of the tumor and a small hemorrhage in the upper cerebellar vermis, from which the patient was asymptomatic (Figs. 1 and 2).

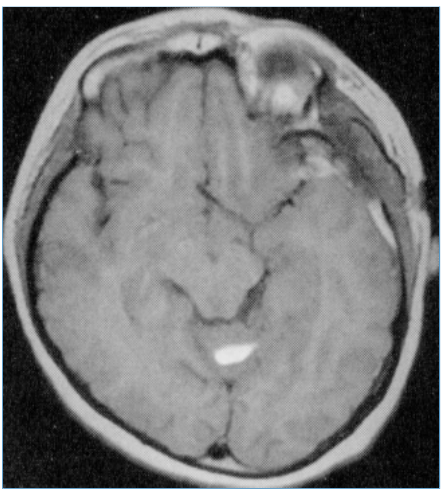

FIGURE 1. Axial T1-weighted magnetic resonance image showing hemorrhage in upper cerebellar vermis in patient who had undergone resection of a craniopharyngioma.

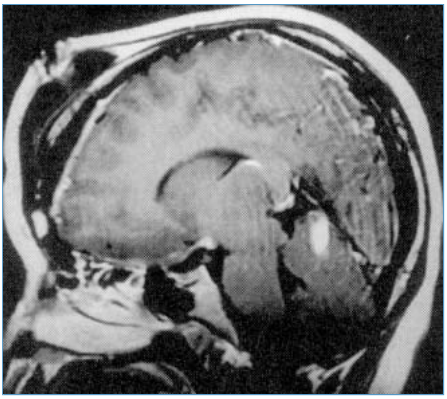

FIGURE 2. Sagittal T1-weighted magnetic resonance image showing hemorrhage in upper cerebellar vermis in patient who had undergone resection of a craniopharyngioma.

Patient 2

The second patient is a 73-year-old man with a history of prostate cancer, non-Hodgkin's lymphoma, and hypertension, who presented with a 6-month progressive loss of vision in the left eye. Imaging studies revealed that the patient had a tuberculum sella meningioma. The patient underwent a left frontotemporal craniotomy in the supine position and removal of the tumor. Blood pressure readings during the operation were in the normal range. The maximum intraoperative blood pressure reading was 170/80.

Postoperatively, the results of the patient's neurological examination were unchanged from those of the preoperative examination, except that the patient was somewhat lethargic. A CT scan of the head obtained the next day showed a good resection of the tumor, a small amount of hemorrhage at the operative site, and a small amount of hemorrhage bilaterally in the cerebellum. The patient's coagulation parameters were normal, both pre- and postoperatively. In the postoperative period, the patient's systolic blood pressure ranged mostly between 160 and 179, with a maximum recorded pressure of 190/62. The patient had an otherwise uneventful postoperative course.

Patient 3

The third patient is a 55-year-old man with a history of mild hypertension who presented with a generalized seizure. A CT scan of the head and a subsequent four-vessel angiogram revealed a large left posterior communicating artery aneurysm and no other abnormalities (Figs. 3 and 4). There was no subarachnoid hemorrhage noted on the CT scan or by lumbar puncture. The patient underwent a left frontotemporal craniotomy in the supine position, at which time, a large, partially thrombosed aneurysm was found. The aneurysm was entirely supratentorial. The neck of the aneurysm was clipped, and the dome of the aneurysm was partially resected. Intra- and postoperatively in the intensive care unit, the blood pressure was never higher than 175/90.

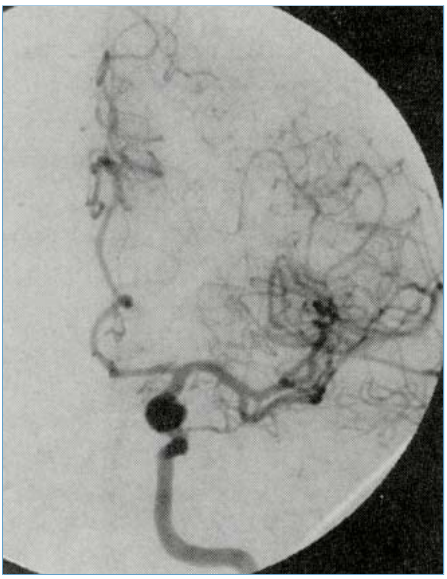

FIGURE 3. Left internal carotid artery angiogram, anteroposterior view, demonstrating a posterior communicating artery aneurysm.

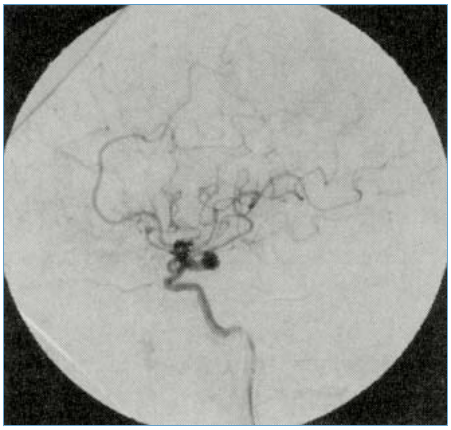

FIGURE 4. Left internal carotid artery angiogram, lateral view, demonstrating a posterior communicating artery aneurysm.

After surgery, the patient was initially somewhat slow to awaken, and when he did fully awaken, he was noted to have a right hemiparesis (3-4/5) and a global aphasia. The coagulation values were all normal at this time. A CT scan was obtained, which showed a slight hypodensity in the left frontal lobe and a small intraparenchymal cerebellar hemorrhage in the vermis and left cerebellum. An angiogram showed no residual aneurysm and an absence of small left anterior cerebral and middle cerebral artery branches that had been present preoperatively. At the end of the angiography, the patient became very agitated and it was difficult to obtain hemostasis at the angiocatheter site. Repeat coagulation studies were very abnormal, consistent with disseminated intravascular coagulation (prothrombin time [PT], 17.6; partial thromboplastin time, >150; platelets, 217,000; and fibrin degradation products, 10-39[normal, <10]).

A subsequent CT scan showed significant expansion of the cerebellar hemorrhage (vermis and right and left cerebella) and obstructive hydrocephalus. Despite transfusion of fresh frozen plasma, ventriculostomy, and removal of the cerebellar hemorrhage, the patient sustained permanent brain stem injury and satisfied clinical brain death protocol 2 days later. When the patient was subsequently considered for organ donation, the results of the blood tests were positive for human immunodeficiency virus. No underlying abnormalities were noted in the cerebellum at surgery or at autopsy.

Patient 4

The fourth patient is a 57-year-old woman who presented with 2 years of progressive apathy, confusion, aphasia, and gait difficulty. A CT scan of the head demonstrated a large meningioma, approximately 6 × 5 × 5 cm, originating from the dura at the junction of the floor and convexity of the middle cranial fossa (Fig. 5). The patient had no history of hypertension and normal coagulation parameters. The tumor was removed via a left frontotemporal parietal craniotomy performed with the patient in the supine position. The maximum intraoperative blood pressure was 160/85. Postoperatively, the highest recorded blood pressure was 170/85.

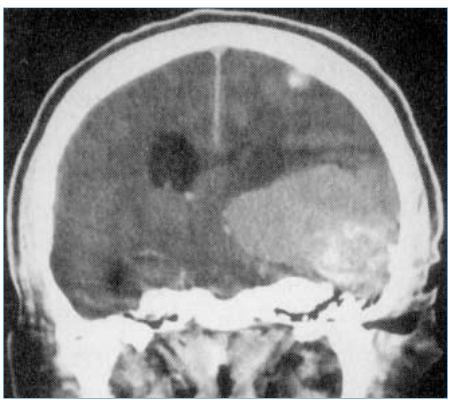

FIGURE 5. Coronal view CT scan enhanced with contrast medium, demonstrating a large, partly calcified meningioma originating from the junction of the floor and convexity of the middle cranial fossa.

A few hours postoperatively, the patient became more lethargic. A CT scan of the head was obtained, and it showed a 2-cm right frontal intraparenchymal hemorrhage (Fig. 6). Within 24 hours, the patient developed a right gaze preference and a mild left hemiparesis. Another CT scan of the head was obtained, and it showed expansion of the right frontal hemorrhage. Coagulation parameters remained normal throughout the postoperative period. The hemorrhage was treated nonsurgically, and the patient experienced a good recovery. By 2 weeks postoperatively, the patient was clinically improved as compared to preoperatively and was gradually improving. The patient is currently independent and neurologically intact.

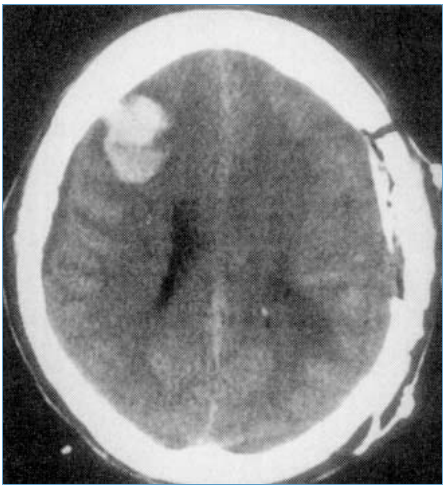

FIGURE 6. Axial view CT scan showing hemorrhage in the right frontal lobe in a patient who had undergone resection of a left frontotemporal parietal meningioma.

Patient 5

The fifth patient is a 69-year-old woman with a history of hypertension and a liver transplant 4 years previously for hepatitis C. She presented with decreased visual acuity bilaterally, and MRI revealed that she had a sellar/suprasellar cystic lesion. Her coagulation parameters were completely normal, except for her PT of 14.0 (normal, <13.3). The patient underwent a right frontotemporal craniotomy in the supine position and aspiration of 3 ml of turbid yellow fluid from the cyst, which demonstrated scattered squamous cells and clusters of uniform ciliated cuboidal cells consistent with a Rathke's cleft cyst. The maximum intraoperative blood pressure was 170/65, and the maximum postoperative blood pressure was 173/70.

Postoperatively, the patient's vision was improved. The PT immediately postoperatively was 14.8, one day later was 15.3, and 2 weeks later was 14.4. Partial thromboplastin time remained in the normal range throughout. The platelet count was 129,000 immediately postoperatively, 91,000 4 days later, and 74,000 on postoperative Day 11. After the operation, the patient was intermittently somewhat lethargic. A CT scan of the head obtained 1 week after the operation showed a right parietal occipital intracerebral hemorrhage (Fig. 7). The patient experienced an otherwise uneventful recovery, and her platelet count began to increase.

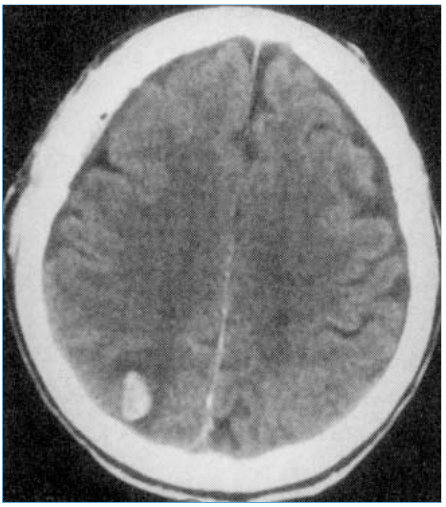

FIGURE 7. Axial view CT scan showing hemorrhage in the right parietal occipital lobe in a patient who had undergone decompression of a Rathke's cleft cyst.

Review of 37 cases

The 37 patients in the study were subdivided into four categories: infratentorial hemorrhage after supratentorial craniotomy (16 patients), infratentorial hemorrhage after infratentorial craniotomy (1 patient), supratentorial hemorrhage after supratentorial craniotomy (6 patients), and supratentorial hemorrhage after infratentorial craniotomy (14 patients). The results for these patients are summarized in Tables 1 and 2.

	Series (Ref. No.)	Age/ Gender	Lesion	Craniotomy Site	Bleed Site	Maximum BP Perioperative	Coagulopathy	Time Bleed Detected	Complication
After supratentorial craniotomy	Konig et al., 1987 (16)	56 M	Sphenoid wing meningioma	L subfrontal	L cerebellum	NA	Yes	Within hours	Death
	Konig et al., 1987 (16)	54 M	ICA aneurysm	R frontotemporal	R/L/vermis cerebellum	"Hypertensive"	Yes	Day 2	Moderate
	Konig et al., 1987 (16)	42 F	Craniopharyngioma	Subfrontal	R/L/vermis	Normal	Yes	Within hours	Death
	Konig et al., 1987 (16)	59 F	Tumor	R occipital	R cerebellum	"Increased"	Yes	Day 3	None
	Modesti et al., 1982 (18)	12 M	Hygroma (medulloblastoma)	L burr holes	L cerebellum	Normal	No	Within hours	Death
	van Clanenberg et al., 1993 (26)	58 M	Metastasis	R parietal	L cerebellum	NA	No	Day 4 (i)	None
	van Clanenberg et al., 1993 (26)	50 M	MCA aneurysm	R frontotemporal	Cerebellar vermis	NA	No	Day 3	Moderate
	Waga et al., 1983 (30)	42 M	AComA aneurysm	R frontotemporal (+SAH)	Cerebellar vermis	Normal	No	Within hours	Moderate
	Yasargil and Yonekawa, 1977 (31)	NA	Ischemia	EC-IC bypass	Cerebellum	>250	NA	Within hours	Death
	Yasargil and Yonekawa, 1977 (31)	NA	Ischemia	EC-IC bypass	Cerebellum	>250	NA	Within hours	Death
	Yoshida et al., 1990 (32)	54 M	AComA aneurysm	R frontotemporal (+SAH)	Cerebellar vermis	"Increased"	NA	Within hours	None
	Yoshida et al., 1990 (32)	43 M	PComA aneurysm SAH	L frontotemporal	L/vermis cerebellum	Normal	NA	Within hours	None
	Yoshida et al., 1990 (32)	59 M	L ICA aneurysm R MCA aneurysm SAH	Bilateral frontotemporal	R/vermis cerebellum	"Increased"	NA	Within hours	Severe
	Brisman et al., 1996 (this study)	24 F	Craniopharyngioma	L frontotemporal (S)	Cerebellar vermis	184/80	No	Day 7 (i)	None
	Brisman et al., 1996 (this study)	73 M	Tuberculum sella meningioma	L frontotemporal (S)	R/L/vermis cerebellum	190/62	No	Within hours	None
	Brisman et al., 1996 (this study)	55 M	PComA aneurysm	L frontotemporal (S)	L/vermis cerebellum	175/90	No	Within hours	Death
After infratentorial craniotomy	Kobayashi et al., 1983 (14)	55 F	Acoustic	R suboccipital (lat)	L pons	Normal	NA	Within hours	Moderate

[a] **BP, blood pressure; L, left; R, right; NA, not available; ICA, internal carotid artery; (i), incidental finding; MCA, middle cerebral artery; AComA, anterior communicating artery; SAH, subarachnoid hemorrhage; PComA, posterior communicating artery; (S), supine position; (lat), lateral position.**

TABLE 1. Infratentorial Hemorrhages*a*

	Series (Ref. No.)	Age/ Gender	Lesion	Craniotomy Site	Bleed Site	Maximum BP Perioperative	Coagu-lopathy	Time Bleed Detected	Compli-cation
After supratentorial craniotomy	Kalfal and Little, 1988 (12)	NA	ICA aneurysm	L frontotemporal	R parietal occipital	NA	No	Within hours	NA
	Modesti et al., 1982 (18)	63 M	Arachnoid cyst	L frontotemporal	R temporal parietal	NA	No	Within hours	Moderate
	Waga et al., 1983 (30)	50 M	ACA aneurysm SAH	R frontotemporal	L frontal	Normal	No	Within hours	Severe
	Waga et al., 1983 (30)	47 F	AComA aneurysm SAH	R frontotemporal	L frontal	Normal	No	Within hours	None
	Brisman et al., 1996 (this study)	57 F	Meningioma	L frontotemporal parietal (S)	R frontal	170/85	No	Within hours	None
	Brisman et al., 1996 (this study)	69 F	Rathke's cleft cyst	R frontotemporal (S)	R parietal occipital	173/76	Yes	Day 7	None
After infratentorial craniotomy	Haines et al., 1978 (7)	65 F	Tic douloureux	R suboccipital (s)	R occipital	165/95	No	Within hours	Moderate
	Haines et al., 1978 (7)	55 F	GPN	R suboccipital (s)	R basal ganglia	200	No	Within hours	Death
	Haines et al., 1978 (7)	41 F	Tic douloureux	R suboccipital (s)	R frontoparietal	170/96	No	Within hours	None
	Haines et al., 1978 (7)	64 F	Anes. dolorosa	R suboccipital (s)	L frontal	168	No	Within hours	Moderate
	Harders et al., 1985 (8)	44 F	Meningioma	Suboccipital (s)	L frontoparietal	NA	NA	NA	Severe
	Harders et al., 1985 (8)	51 F	Acoustic	Suboccipital (s)	B/L frontotemporal	NA	NA	NA	Death
	Harders et al., 1985 (8)	58 M	Meningioma	Suboccipital (s)	L parietal	NA	NA	NA	Moderate
	Kalfas and Little, 1988 (12)	NA	Tumor	Suboccipital (s)	NA	NA	No	NA	NA
	Seiler and Zurbrugg, 1986 (20)	66 F	Acoustic	R suboccipital (lat)	R parietal	250	No	Within hours	Severe
	Seiler and Zurbrugg, 1986 (20)	64 F	Meningioma	R suboccipital (s)	L parietal R basal ganglia	150/70	No	Within hours	Death
	Seiler and Zurbrugg, 1986 (20)	59 F	Acoustic	R suboccipital (s)	R parietal occipital	160/90	No	Within hours	Severe
	Standefer et al., 1984 (25)	55	Parotid cancer	Suboccipital (s) + C1–C3 laminectomy	Temporal	NA	No	NA	Death
	Standefer et al., 1984 (25)	59	Meningioma	Suboccipital (s)	Basal ganglia	"Increased"	No	Day 7	Death
	Waga et al., 1983 (30)	39 M	Syrinx	Suboccipital (prone) + C1–C3 laminectomy	B/L parietal	Normal	No	Within hours	Death

[a] **BP, blood pressure; NA, not available; ICA, internal carotid artery; L, left; R, right; ACA, anterior cerebral artery; SAH, subarachnoid hemorrhage; AComA, anterior communicating artery; (S), supine position; (s), sitting position; GPN, glossopharyngeal neuralgia; Anes., anesthesia; B/L, bilateral; (lat), lateral position.**

TABLE 2. Supratentorial Hemorrhages*a*

Of the 37 patients, gender was specified in 31 patients, of whom 15 were men and 16 were women. Age was recorded for 33 patients and ranged from 12 to 73 years, with a mean age of 52.8 years. Twenty-nine of the 33 patients (88%) were aged 40 to 70 years.

There was great variability for the patients' underlying lesions. Seventeen patients were operated on for tumors, and 10 patients were operated on for aneurysms. Seventeen operations were performed on the right side, nine were performed on the left side, three were midline or bilateral, and in eight cases, the side of the operation was unspecified. Thirteen of the 16 supratentorial operations (81%) involved a frontal or frontotemporal exposure and procedures in the deep sylvian fissure and paraclinoid area. Thirteen of the 15 infratentorial operations (87%) were performed in the sitting position. Operative positioning was not explicitly specified for patients in the literature with remote hemorrhages after supratentorial craniotomies, although, presumably, the supine position was used for most if not all of these patients.

Infratentorial hemorrhages involved the cerebellum in 16 cases and the pons in 1 case. In two cases of cerebellar hemorrhage, the exact sites of the hemorrhages were not specified. Of the remaining 15 infratentorial hemorrhages, 10 involved the cerebellar vermis (67%) and 4 were limited to a cerebellar hemisphere. Two of the cerebellar hemorrhages were associated with subarachnoid blood in the posterior fossa. Supratentorial hemorrhages occurred on the right side in eight patients, on the left side in five patients, bilaterally in three patients, and the side of hemorrhage was unspecified for two patients. The sites of supratentorial hemorrhages were specified for 19 patients. Although location of supratentorial hemorrhages was variable, in 16 of 19 patients (84%), the hemorrhages occurred in superficial and lobar sites, as opposed to deep, central sites typical of hypertensive hemorrhages. Only 3 of 19 supratentorial hemorrhages were in the basal ganglia region.

Eight patients had histories of hypertension, whereas 13 had no history of hypertension. For 16 patients, history of hypertension was not mentioned.

Eight patients had perioperative blood pressure readings that were recorded as “normal.” Ten patients had maximum perioperative blood pressure readings that ranged from 150 to 190 mm Hg systolic and up to 96 mm Hg diastolic. Five patients had perioperative blood pressure that was recorded as“increased” or “hypertensive”

without specifying exact values. Only 4 of 35 patients had documented maximum systolic perioperative blood pressures greater than or equal to 200 mm Hg. For 10 patients, no information about perioperative blood pressure was specified.

Information about perioperative coagulation status was available for 27 patients. There was some coagulation abnormality noted preceding the hemorrhage in only five patients. None of the patients had been noted to have been taking aspirin or other nonsteroidal medications, which could have affected platelet function.

Cerebrospinal fluid (CSF) drainage (lumbar drain or ventriculostomy) was not used for any of our five patients. Of the remaining 32 patients, CSF drains were rarely used; no patients had lumbar drains or ventriculostomies, one patient had an epidural drain that drained some CSF, and two patients had epidural and basal cistern drains that drained CSF.

The time postoperatively at which the remote hemorrhage was discovered was specified in 32 cases. In 25 of the 32 cases (78%), the bleed was detected within hours of the operation. Three cases were detected on the 2nd or 3rd day after surgery, and the other four cases were all detected by the end of the 1st week after surgery. Two hemorrhages were detected incidentally.

In none of the 35 cases was a previously undiagnosed lesion found to underlie the remote hemorrhage site, despite that almost all patients had imaging studies, many had contrast studies, and many had angiograms. Three patients had no underlying lesion found at direct exploration, and four patients had no underlying lesion found at autopsy. There was one patient with a previously resected medulloblastoma who, after drainage of a left frontoparietal subdural hygroma via multiple burr holes, sustained a large cerebellar hemorrhage, possibly related to his known underlying pathological abnormality.

Ten patients had no permanent complication from their remote hemorrhage. Eight patients were left with moderate disabilities, and five patients were left with severe disabilities. There were 12 mortalities.

DISCUSSION

Intracerebral hemorrhage occurring remote from the site of craniotomy is an uncommon neurosurgical complication that is often associated with significant morbidity and mortality. There are few reports of this entity in the literature, although it is possible that this complication is not rare.

Remote postoperative intracerebral hemorrhage should be distinguished from other types of iatrogenic intracranial hemorrhage. Postcraniotomy hemorrhage most commonly occurs at the site of surgery and is usually attributed to various aspects of inadequate intraoperative hemostasis (6). Postcraniotomy hemorrhage can also occur in remote locations, including subdural (15), epidural (5, 12, 17), and intracerebral. Of note also are several reports of bleeding into intra-axial brain tumors after placement of a ventricular drain or ventriculoperitoneal shunt (4, 28, 29).

Intracerebral hemorrhage can also occur after noncraniotomy procedures. The most common of these is the carotid endarterectomy, which has a 0.4 to 0.7% rate of postoperative intracerebral hemorrhage in the vascular distribution of the ipsilateral carotid, thought to be possibly related to a hyperperfusion phenomenon (2, 22). There is one reported case of cerebellar hemorrhage after cervical laminectomy performed in the sitting position (3).

Intracranial hemorrhage can also occur after nonneurosurgical operations, but its occurrence is very rare. One recent review of nearly 25,000 general surgery operations found only one postoperative intracerebral hemorrhage (19). Cases of intracranial hemorrhage have also been described after spinal analgesia and after lumbar myelography, most of which were subdural hemorrhages but five of which were intracerebral hemorrhages (27).

The other major source of iatrogenic intracerebral hemorrhage is administration of anticoagulants, particularly with higher doses, with more abnormal coagulation parameters, with thrombolytics, and after stroke (1, 10). In one study of patients taking warfarin, 75% of those that developed subsequent intracerebral hemorrhages had PTs that were more than 1.5 times normal (13).

Most of the remote hemorrhages we reviewed presented within hours of surgery, at times immediately afterwards, suggesting that most of these hemorrhages develop during or soon after surgery. Furthermore, the development of a remote hemorrhage was apparently unrelated to the underlying pathological abnormality for

which the craniotomy was performed. There were, however, certain clear predilections for the site and position of operation and the site of hemorrhage.

Remote postoperative intracerebral hemorrhages were apparently not caused by hypertension; patients often had no history of hypertension, often had perioperative blood pressures that were normal, and often had hemorrhages in locations atypical for hypertensive hemorrhages. In the cases in which elevated perioperative blood pressures were observed, this may have been secondary to the intracerebral hemorrhage rather than an inciting cause. Intracerebral hemorrhages remote from craniotomy also did not seem to be caused by coagulopathy, CSF drainage, or underlying lesions with which they were only infrequently associated.

It is possible that remote postoperative hemorrhages are caused by transient vascular or mechanical factors. The medial sylvian/tentorial location of supratentorial procedures associated with this phenomenon suggests that disturbances of deep venous drainage could occur. Furthermore, the association of suboccipital procedures that induced remote hemorrhages with the sitting position, suggests that mechanical displacement of the brain may play a role as well. Finally, aggressive intraoperative dehydration and CSF aspiration may also predispose to shifts of the brain that could contribute to intracerebral hemorrhages.

Abnormal results of a neurological examination in the early postoperative period should suggest this entity, which is then best identified by CT scanning. Once a remote hemorrhage is identified, blood pressure and coagulation parameters should be kept within normal limits, and if the hemorrhage is large enough, surgical evacuation may be necessary. For patients who do well, follow-up imaging studies enhanced with contrast media are recommended. A follow-up angiogram is not routinely recommended and is suggested only if the clinician is suspicious of a vascular lesion for other reasons.

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COMMENTS

Brisman et al. describe a series of five cases of intracerebral hemorrhages occurring remote from the craniotomy sites. They also review the literature, which reveals an additional 32 cases. It is not too surprising that patients who underwent posterior fossa procedures in the sitting position were found to have supratentorial hemorrhages. The mechanical changes that could be associated with some degree of brain shift and tension on cerebral veins probably explain this phenomenon.

Less easy to understand is the phenomenon of a posterior fossa-cerebellar vermis hemorrhage in the setting of a craniotomy. It is of interest that frontal temporal approaches for which the basal subarachnoid cisterns were exposed seemed to be the predominant situation in which this complication occurs. This probably relates in some way to an indirect effect of basal subarachnoid supratentorial surgery on the venous drainage of the cerebellar vermis. Until we understand the mechanism of this complication, it is unlikely that we will be able to prevent it. The authors' work indicates, however, that intraoperative hypertension, coagulopathy, and the use of a lumbar cerebrospinal fluid drain are probably not important technical features of a procedure that would predispose the patient to this complication.

Ralph G. Dacey, Jr.

St. Louis, Missouri

Parenchymal brain hemorrhage at a remote site is a well-recognized but, fortunately, rare complication of craniotomy. The cause of the bleed often is not obvious, because the more common predisposing factors to brain hemorrhage, such as hypertension or bleeding diathesis, generally are absent. At Cornell, we have used spinal drainage on thousands of patients undergoing craniotomies, and postoperative brain hemorrhage has been rare; therefore, I do not think that brain shift as the result of spinal fluid drainage predisposes to hemorrhage.

One thing that can result in brain hemorrhage is venous obstruction from extreme rotation and flexion of the neck. In operations involving the cerebellopontine angle, it is tempting to rotate and flex the neck excessively. In obese patients particularly, this can start a chain of events beginning with the obstruction of jugular venous drainage, then cerebellar swelling, and ending in cerebellar hemorrhage. The same is possible in a supratentorial craniotomy if the head is excessively rotated and angulated. Of course, venous obstruction may not have played a role in the cases described in the present report, but surgeons still should not forget about venous drainage when positioning patients.

Russel H. Patterson, Jr.

New York, New York

The authors examine a perplexing complication in neurosurgery, which is the occurrence of perioperative intracerebral hematomas at sites distant from the craniotomy. The topic is important, and the discussion is interesting. However, this retrospective analysis from a variety of cases does not lend insight into the incidence or potential causes for this occurrence.

Marc R. Mayberg

Seattle, Washington

The authors describe an important complication of neurosurgical procedures that is not often discussed in the literature. We have had two such occurrences in our practice. The first was a 71-year-old man with a lateral

third sphenoid wing meningioma. Simpson Type II removal was accomplished with no difficulties. The total anesthesia time was 6 hours. The patient failed to awaken from surgery. The postoperative computed tomographic scan showed multiple intracerebral hemorrhages distant from the tumor site, principally on the opposite side. There were no hypertensive crises during surgery, the patient was not overloaded with fluids, and there was no coagulopathy present. The patient was in a typical position for a pterional craniotomy. The second patient was a 67-year-old man with a 3.5-cm acoustic neuroma. The patient underwent a suboccipital craniotomy, retrolabyrinthine petrosectomy, and retrosigmoid removal of a rather soft and necrotic tumor while in a supine position. Postoperatively, the patient remained lethargic. A computed tomographic scan showed multiple subcortical hemorrhages over the convexity of the opposite cerebral hemisphere in conjunction with some subarachnoid hemorrhage as well. Again, there were no hypertensive crises during surgery, the patient was not overloaded with fluids, and there was no coagulopathy. The common denominators for both patients, possibly contributing to these complications, were their advanced age and the supine position with the head turned toward the side opposite from the tumor (less so in the patient with meningioma). It is conceivable that turning the head and neck may have resulted in a venous outflow obstruction on the side contralateral to the tumor, resulting in venous infarcts. Greatest care, therefore, should be exercised to prevent any venous outflow obstruction, especially in the elderly.

Ivan S. Ciric

Evanston, Illinois

Key words: Complication; Craniotomy; Hemorrhage; Hypertension; Intracerebral, Remote

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IMAGE GALLERY

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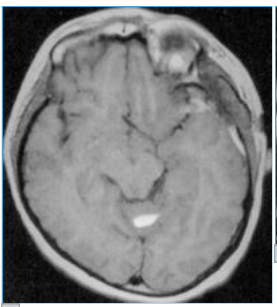
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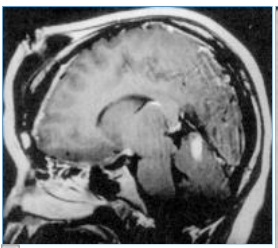
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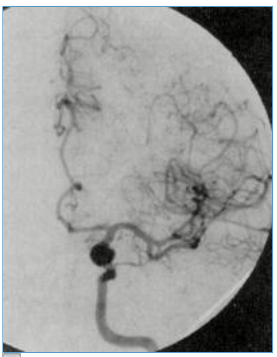
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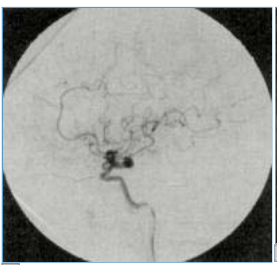
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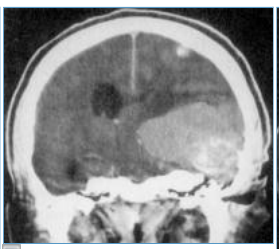
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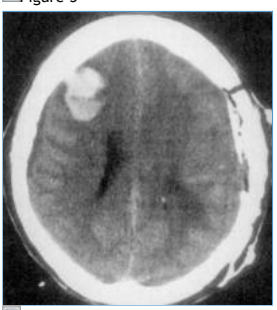
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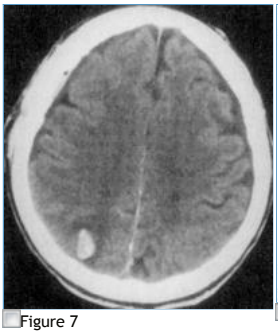

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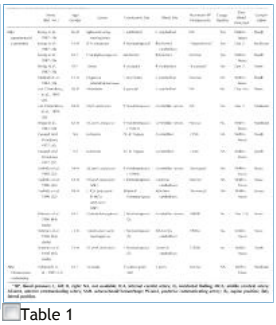

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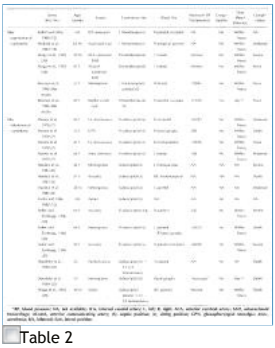

Table 2

Back to Top