A new trend in operative technique for intracerebral hemorrhage: a comparative study of stereotactic endoscopic removal and stereotactic catheter drainage

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The development of less invasive methods to evacuate intracerebral hematomas (ICHs) has improved outcome in patients with traumatic brain injury. Eighteen patients with ICHs underwent surgery via one of two methods: stereotactic endoscopic removal (SER) or stereotactic catheter drainage (SCD). The outcome results were then compared. The patient population was composed of 11 men and seven women with a mean age of 53.3 years (range 33-81 years), all suffering from ICH in the basal ganglia. The mean hematoma volume was 34.4 ml (range 23-105 ml). All patients had major neurological deficits, but showed no sign of transtentorial herniation.

Ten patients underwent SCD and eight had SER. All procedures were performed within 24 hours of insult. After local anesthesia was induced in the patient, an intracranial pressure (ICP) monitoring catheter and an Oztuki cannula were placed through separate burr holes in the skull. Using the SER technique, the ICH was removed using suction and forceps through the side window of the cannula until the ICP had decreased significantly. Hemostasis was attained by lesioning with a Nd-YAG laser. In the SCD procedure, we placed a silicone catheter into the hematoma to drain it and then added urokinase. The hematoma was drained for 3 to 5 days in the SER method and 7 to 10 days in the SCD method. Rebleeding occurred in one of the early cases in which we used the SER procedure. At follow-up evaluation, the mortality rate was 13% in the SER group and 10% in the SCD group. The patients in whom outcome was most improved from these treatments were those who had been admitted with an impaired level of consciousness.

Stereotactic catheter drainage is a precise, safe, and brief procedure with a very low rebleeding rate, but its outcome effect was more delayed than other procedures. Stereotactic endoscopic removal can easily replace SCD, with a similar mortality rate. Both procedures can be accomplished under direct visualization so as to eliminate any undesirable event or outcome.

Key Words * intracerebral hematoma * stereotactic endoscopic removal * stereotactic catheter drainage * urokinase

The management of intracerebral hematomas (ICHs) is still controversial.[9,23,24,32,34] Despite the best efforts of experts in many medical fields, the prognosis for patients suffering from spontaneous

hypertensive ICH remains poor.[30] Some authors advocate early surgery in spite of the additional risk of damaging intact brain tissue.[1,15,17,19,28,31,33] Others prefer a nonsurgical approach.[7,13,14,20,23] The aim of operative treatment should be the removal of as much of the clot as possible, with minimal disruption of surrounding brain tissue, to reduce local and generalized intracranial pressure (ICP), and to preserve cerebrospinal fluid (CSF).[6] The two generally accepted surgical options to treat spontaneous ICH are conventional open craniotomy or computerized tomography (CT)-guided stereotactic evacuation of the hematoma; both procedures are performed with the patient under local anesthesia and are followed by hematoma lysis.[18,25] The standard operative treatment for ICH, consisting of craniotomy and clot evacuation under direct vision, is not difficult or time-consuming. Depending on clot location and associated medical conditions that may be present, the operative mortality rate can be extremely high, ranging from 20% to 90%. These grim results have stimulated a search for a more tolerable, less traumatic, and safer methods of clot removal.[2,19,27] Less traumatic methods of clot evacuation have focused on stereotactic methods, instillation of fibrinolytic agents, mechanically assisted aspiration, and more recently, endoscopic methods. Several authors reported the use of an endoscope fitted with irrigation and suction devices and a laser, with or without stereotactic capabilities, in evacuating spontaneous ICH.[1,30,35] Their results were not encouraging. We compare our results using two stereotactic operative methods.

CLINICAL MATERIAL AND METHODS

Patient Population

Between September 1993 and October 1995, we surgically treated 81 patients presenting with spontaneous ICH at our hospital. Twenty-three patients underwent conventional microscopic craniotomy, 44 patients underwent CT-guided stereotactic catheter placement with urokinase infusion and drainage, and 14 patients underwent CT-guided stereotactic endoscopic hematoma removal and silicone tube insertion within 24 hours of the insult. Of these 81, 18 patients (seven women and 11 men), with a mean age of 53.4 years (range 33-81 years), were included in this study. All patients had a hypertensive ICH in the basal ganglia. Informed consent for treatment was obtained from all the patients and/or their relatives. Patients were followed for at least 6 months after treatment. The 18 patients were chosen on the basis of the following criteria: a decreased level of consciousness; no clinical sign of herniation; a hematoma with a minimum diameter of 3 cm; a hematoma present less than 24 hours and in a ganglionic location; no aneurysm or arteriovenous malformation; and no systemic bleeding disorder.

Radiographic Assessment

An initial CT scan was obtained in all patients, and the diameter and volume of the hematoma were assessed. Patients in whom a vascular malformation or an aneurysm were suspected underwent additional angiography within 24 hours.

OPERATIVE TECHNIQUES

All operations were performed after local anesthesia was induced in the patient. We placed the ring from a Codman-Roberts-Wells stereotactic system on the patient's head and 5-mm axial CT slices were obtained through the hematoma. A trajectory was calculated from the point of entry through the main axis of the hematoma using cartesian coordinates x, y, and z. The patient was taken to the operating room and the stereotactic aiming bow was placed in the patient's headring after the coordinate points were computed. After making a 2-cm scalp incision, a burrhole was made with the airtome. The exposed dura

was coagulated and incised in a cruciate pattern.

Stereotactic Catheter Placement and Urokinase Drainage

A silicone ventricular drainage catheter was placed stereotactically, and careful manual hematoma aspiration was attempted. We did not use mechanical hematoma evacuators. A subcutaneous tunnel for the distal end of the tube was created, several pieces of coagulative material were placed into the burrhole, and the wound was closed. This was followed by a CT scan to ascertain correct catheter placement within the hematoma.

Fig. 1. Artist's rendering of the stereotactic endoscopic system. An Otzuki guiding cannula (8 mm in diameter, 20 cm long, with a 1 X 2 cm side window) is attached to a stereotactic Codman-Roberts-Wells headframe using a specially designed stereotactic guiding block. A thin, rigid (variangled, 2 mm in diameter) telescope is introduced into this guiding cannula. Various flexible microsurgical instruments such as suction tubes, forceps, and laser fibers can be used through the side window of the guiding cannula.

Stereotactic Endoscopic Removal

Just in front of the burr hole, a parenchymal ICP monitoring catheter was placed through a second drill hole. A silicone catheter was placed stereotactically and an Otzuki guiding cannula (8 mm in diameter, 20 cm long, with a side window) was inserted through the specially designed stereotactic guiding block.[26] The stylet was removed at the target point and a thin, rigid telescope (angled, 2 mm in diameter) was introduced into the guiding tube. Various flexible microsurgical instruments, such as suction tubes, forceps, and laser fibers, were inserted through the window of the guiding tube (Fig. 1). Under direct vision, stepwise removal of the hematoma was accomplished until the ICP was significantly reduced (Fig. 2). This procedure was followed by placement of an indwelling silicone catheter in the center of residual hematoma.

Fig. 2. Intraoperative photograph obtained using a rigid endoscope showing a dark-brown hematoma and adjacent brain tissue. The hematoma can be aspirated with minimal suction under direct vision and without injury to brain tissue.

Lysis Protocol

Each patient received 6000 U urokinase in 5 ml saline, which was injected into the hematoma cavity every six hours. The catheter was closed after each administration of urokinase and saline and reopened and drained into a conventional CSF collection system at 0 cm of pressure after 2 hours. The first control CT scan was obtained approximately 12 hours after treatment initiation, and all subsequent CT scans were obtained every 48 hours. After the final control CT scan, the catheter was removed. The coagulation status was assessed routinely.

Follow-up Evaluation

Follow-up information was obtained for all patients 6 months after treatment. The results were graded according to the Glasgow Outcome Scale[13] score, ranging from Grade V (good recovery) to Grade I (dead).

Statistical Analysis

Statistical significance was analyzed using a commercially available computer software (SAS, Windows version 6.11, Cary, NC). We used the Pearson chi-square test to compare groups and a discriminant analysis to assess the retrospective weights of the prognostic factors.

Fig. 3. Case 15. Computerized tomography (CT) scans obtained in a 54-year-old man with a right putaminal intracerebral hemorrhage. Upper: Admission CT scan showing a moderate-sized hematoma (Day 0). Lower: Cranial CT scan 24 hours after insertion of the silicone tube and administration of 12000 U of urokinase (Day 1).

RESULTS

Stereotactic Catheter Placement and Urokinase Drainage

Intraoperative blood aspiration via the inserted catheter was possible in all patients in varying degrees. The amount of clot aspirated ranged from 4 to 14 ml (mean 7.7 ml), and the removal rate was 23.9%. There was no substantial decrease in hematoma volume using the SCD procedure; as documented on postoperative control CT scan (Fig. 3). The amount of aspirated clot did not correlate to the length of time between ictus and the stereotactic procedure.

Fig. 4. Case 8. Computerized tomography (CT) scans obtained in an 80-year-old woman with a large right putaminal intracerebral hemorrhage. Upper: Admission CT scan showing compression of the right lateral ventricle and midline shift to the left with some intraventricular hemorrhage (Day 0). Lower: Cranial CT scan obtained approximately 12 hours after the patient underwent the SER procedure. Note the significant decrease of midline shift and reduction of hematoma size (Day 1) and the artifact caused by the trajectory of the inserted ventricular and parenchymal catheters.

Stereotactic Endoscopic Removal

Intraoperative endoscopic hematoma removal was easier using the SER procedure than using the SCD method. The amount of clot aspirated ranged from 10 to 57 ml (mean 23.5 ml), producing a removal rate of 54.1% (Fig. 4). We were very careful not to touch the part of clot that was attached to the wall so as not to cause vascular injury and rebleeding. Active bleeding was controlled by irrigation and laser coagulation. Patients' ICPs ranged from 12 to 45 mm Hg (mean 24.3 mm Hg); their final ICPs ranged from 3 to 15 mm Hg (mean 6.1 mm Hg). The mean reduction of ICP during SER was 74.5% (Table 1). The removal of the hematoma using the SER method allowed a rapid reduction of ICP in most patients without causing a large lesion.

TABLE 1 CHANGES IN INTRACRANIAL PRESSURE (ICP) RELATED TO VOLUME OF HEMATOMA REMOVED IN EIGHT PATIENTS UNDERGOING STEREOTACTIC ENDO- SCOPIC REMOVAL PROCEDURES		
Case No.	ICP Change	Hematoma Volume Removed
1	12 mm Hg	19 ml
2	17 mm Hg	10 ml
3	14 mm Hg	17 ml
4	9 mm Hg	18 ml
5	30 mm Hg	57 ml
6	28 mm Hg	19 ml
7	10 mm Hg	12 ml
8	25 mm Hg	36 ml

Hematoma Volume and Location

All hematomas (11 in the right hemisphere and seven in the left) were located deep within the basal ganglia and involved the internal capsule in the area of distribution of the lenticulostriate arteries. Hematoma volume ranged from 23 to 105 ml (mean 37.2 ml) (Table 2).

TABLE 2 CLINICAL AND OUTCOME DATA IN 18 PATIENTS WITH SPONTANEOUS INTRACEREBRAL HEMATOMA*									
Case No.	Age (yrs), Sex	Hematoma Volume(ml)		Location in BG	Admission Symptoms	IVH Present	Operative Method	Complication	GOS Score
		Vol 1	Vol 2						
1	33, M	27	8	rt	hemiparesis	—	SER	—	V
2	38, M	20	10	lt	dysphasia/ hemiparesis	—	SER	—	V
3	44, F	28	11	rt	hemiparesis	—	SER	—	V
4	50, M	24	6	rt	hemiparesis	+	SER	—	V
5	52, M	80	23	rt	stupor/hemi- paresis	+	SER	rebleeding	I
6	57, F	40	21	lt	dysphasia/ hemiparesis	—	SER	—	III
7	73, F	23	11	rt	somnolent	—	SER	—	V
8	81, F	105	69	rt	stupor/hemi- paresis	+	SER	cardiac arrest	II
9	33, M	25	21	rt	hemiparesis	—	SCD	—	V
10	37, M	20	16	rt	hemiparesis	—	SCD	—	V
11	41, M	38	34	lt	semicoma	+	SCD	cardiac arrest	I
12	45, M	35	30	rt	hemiparesis	—	SCD	—	IV
13	47, F	33	27	rt	hemiparesis	—	SCD	—	V
14	52, F	36	30	rt	hemiparesis	—	SCD	—	IV
15	54, M	23	9	lt	dysphasia	—	SCD	—	V
16	67, M	65	52	lt	dysphasia/ hemiparesis	+	SCD	—	III
17	77, M	23	11	lt	stupor/hemi- hemiparesis	+	SCD	pulmonary edema	I
18	79, F	24	15	lt	semicoma	—	SCD	pulmonary edema	II

* BG = basal ganglia; GOS = Glasgow Outcome Scale; IVH = intraventricular hemorrhage; SER = stereotactic endoscopic removal; SCD = stereotactic catheter drainage; Vol 1 = preoperative hematoma volume; Vol 2 = postoperative hematoma volume; — = absent; + = present.

Prognostic Factors

The patient's level of consciousness, the intraventricular extension of blood, the volume of hematoma, and the patient's age correlated well with a poor outcome in decreasing order of frequency (Table 3).

TABLE 3 MEAN VALUES IN PATIENTS WITH A FAVORABLE OUTCOME AND AN UNFAVORABLE OUTCOME AND LEVEL OF SIGNIFICANT DIFFERENCE*			
Variable	Favorable Group	Unfavorable Group	p Value
GCS	12.5	4.6	0.0001
IVH	4 of 5 patients	1 of 13 patients	0.0007
hematoma volume	27.6 ml	52.0 ml	0.0226
patient age	48.5 yrs	66 yrs	0.0304
* Values are expressed as mean values. Abbreviations: GCS = Glasgow Coma Scale; IVH = intraventricular hemorrhage.			

Computerized Tomography-Monitored Hematoma Reduction

Computerized tomography was used to monitor hematoma dissolution in all patients and revealed that 17 of 18 patients experienced near-complete dissolution of their clot. Medical complications occurred in four patients but we did not discern any systemic side effects related to urokinase administration. Many patients, especially the patient in Case 7, showed immediate improvement (within 24 hours) of their drowsiness or stupor. The initial volume reduction of the hematoma after operation was more marked using the SER procedure than the SCD method. Rebleeding occurred in Case 5 and that patient died. Total drainage time ranged from 3 to 5 days in the patients undergoing SER and 5 to 9 days in the patients undergoing SCD.

Results of Follow-Up Study

At follow-up evaluation, three patients had died (16.7%), two in the SCD group (20%) and one in the SER group (12.5%). Our first patient (Case 11), who was admitted in a semicomatose condition, died. The second patient, who was admitted in a stuporous condition, suffered cardiac arrest during his stay in our intensive care unit. The third patient died from rebleeding after the SER procedure. Nine patients (50%) were classified as Grade V according to the Glasgow Outcome score (Cases 1-4, 7, 9,10,13,15), two patients (11.1%) were classified as Grade IV, two (11.1%) were Grade III, and two (11.1%) were Grade II.

DISCUSSION

The natural course of spontaneous ICH leads to a 30-day mortality rate of 45%.^[3] McKissock, et al.,^[20] found no group of surgically treated patients for whom outcome was better than for patients treated without surgery. They also determined that only one-half of the patients with deep hemorrhages survived. A prospective study from Finland,^[14] composed of 52 patients, has proposed that surgical intervention has no advantage over conservative therapy. Little progress has been made in highlighting the pathophysiology of ICH,^[3] and there is great controversy about patient selection for respective treatments. It is now generally recommended in the European and world literature that patients with smaller hematomas who are alert, stable, or improving should be treated medically and that patients with larger hematomas who show progressive neurological deficit, prolonged functional impairment, and intracranial hypertension should be treated surgically.

During the early period after ictus, ICHs may cause neurological deterioration as a result of an increasing mass effect caused by surrounding edema,[10] and this mass effect may last up to 4 weeks after the bleeding, even with decreasing density of the clot.[4,5]

This deterioration does not always respond to osmotherapy or steroids alone, and, therefore, removal of hematoma should be accomplished as soon as possible (within 24 hours of insult) to decompress the clot (to 30-70 ml), decrease ICP, which prevents secondary deterioration, and to improve perifocal vasogenic edema and local cerebral blood flow.[31]

Debate in Europe is ongoing as to which method is safest and most effective. A direct open surgical approach seems best when evacuating large lobar hemorrhages. On the other hand, the results of such surgery in hematomas within the basal ganglia and other deep structures are unacceptable.[6] This type of surgical approach for decompression and evacuation of the hematoma can cause further tissue damage. Elevated ICP may be decreased by surgery, improving chances of survival. Removal of the clot may diminish secondary tissue destruction and edema in the vicinity of the hematoma, either by preventing compartmental pressure changes and consecutive reduction of the blood flow perfusion pressure or by removing the changes caused by toxic blood byproducts.[1] Fibrinolysis aids rapid dissolution of the remaining blood. The aim is to achieve a mass reduction as well as to reduce the extension of perifocal edema and minimize the amount of tissue damage. A urokinase washout can be performed for up to 7 days after the bleeding.[16] Mohadjer and colleagues[21,22] have reported good results with stereotactic evacuation and urokinase lysis of cerebral and cerebellar hemorrhage, after demonstrating that urokinase lacks neurotoxicity in an animal model.[21] Lerch, et al.,[18] published data on 58 patients who underwent stereotactic puncture of a spontaneous ICH. They instilled 5000 U urokinase after calculating that the residual hematoma was less than 20% of its original volume, and they repeated the administration of 5000 U urokinase up to six times. This led to a 15% rate of new bleeding among the 46 patients who received urokinase therapy. Niizuma and coworkers[25] reported a 7% rate of new bleeding. Hokama, et al.,[12] however, have presented sufficient data to support the use of CT-guided stereotactic hematoma evacuation without subsequent lysis. Other investigators believe that endoscopic removal proved to be superior to medical treatment alone in a group of 100 patients.[1] However, endoscopic removal did not prove to be superior to medical treatment alone in patients suffering from putaminal or thalamic hemorrhage; these patients represent more than one-half of the entire patient population with ICH.[8] The more elegant methods for removal of deep-seated hematomas are ultrasound-guided endoscopy or stereotactic subtotal evacuation, followed by placement of a silicone catheter for urokinase administration and washout.[1] Stereotactically controlled endoscopic evacuation permits localization of the lesion, and removal of the clot is performed under optic control, which may be important in cases of cryptic arteriovenous malformations. This high-tech method may be simple, fast, safe, and effective. As opposed to the SCD procedure, stereotactically guided endoscopy allows continuous intraoperative volume removal.[1] Urokinase or other fibrinolytic substances may also be administered. In our series, use of the SER method made it easier to remove the hematoma and decrease ICP than did the SCD method, although the mortality, morbidity, and rebleeding rates were similar for both.

The patient's initial level of consciousness, hemorrhage size, and intraventricular extension of blood have proven to be accurate predictors of outcome. Less commonly, age, sex, hypertension, and mass effect may indicate harmful effects on outcome in patients with ICH.[11,29] In our study, the level of consciousness, intraventricular extension of blood, volume of hematoma, and age were well-correlated with a poor outcome; these occurred in order of decreasing frequency.

Many patients in our study showed immediate improvement in their level of consciousness. This seemed to be related to the CT-documented decrease of their hematoma size. For such patients, stereotactic treatment proved safe and only minimally distressing. Because these patients regained better levels of consciousness soon after treatment initiation, they could be mobilized earlier for physiotherapy, and this led to a decrease of secondary complications such as pneumonia or pulmonary embolism. Neurological deficits caused by eloquent tissue destruction were not affected by this method. Although the first results are promising, a large randomized clinical trial is needed for evaluation of the methods reported.

CONCLUSIONS

Given the right indications, patients suffering from spontaneous ICH may benefit from stereotactic hematoma lysis, with or without use of endoscopy. Stereotactic catheter drainage is a simple, precise, safe, and brief procedure with very low rebleeding and mortality rates; however the effect of surgery seemed somewhat delayed. On the other hand, SER can replace SCD and allows for direct visualization. Stereotactic endoscopic removal also shortens the hospital stay.

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Manuscript received August 15, 1996.

Accepted in final form September 16, 1996.

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