Early endoscope-assisted hematoma evacuation in patients with supratentorial intracerebral hemorrhage: case selection, surgical technique, and long-term results

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Object. Currently, the effectiveness of minimally invasive evacuation of intracerebral hemorrhage (ICH) utilizing the endoscopic method is uncertain and the technique is considered investigational. The authors analyzed their experience with this method in terms of case selection, surgical technique, and long-term results.

Methods. The authors performed a retrospective analysis of the clinical and radiographic data obtained in 68 patients treated with endoscope-assisted ICH evacuation. Rebleeding, morbidity, and mortality were recorded as primary end points. Hematoma evacuation rate was calculated by comparing the pre- and postoperative CT scans. Glasgow Coma Scale scores and scores on the extended Glasgow Outcome Scale (GOSE) were recorded at the 6-month postoperative follow-up. The technical aspect of this report explains details of the procedure, the instruments that are used, the methods for hemostasis, and the role of hemostatic agents in the management of intraoperative hemorrhage. The pertinent literature was reviewed and summarized.

Results. All surgeries were performed within 12 hours of ictus, and 84% of the surgeries were performed within 4 hours. The mortality rate was 5.9%, and surgery-related morbidity occurred in 3 cases (4.4%). The hematoma evacuation rate was 93% overall—96% in the putaminal group, 86% in the thalamic group, and 98% in the subcortical group. The rebleeding rate was 1.5%. The mean operative time was 85 minutes, and the average blood loss was 56 ml. The mean GOSE score was 4.9 at 6-month follow-up. The authors acknowledge the limitations of these preliminary results in a small number of patients.

Conclusions. The data suggest that early endoscope-assisted ICH evacuation is safe and effective in the management of supratentorial ICH. The rebleeding, morbidity, and mortality rates are low compared with rates reported in the literature for the traditional craniotomy method. This study also showed that early and complete evacuation of ICH may lead to improved outcomes in selected patients. However, the safety and efficacy of endoscope-assisted ICH evacuation should be further investigated in a large, prospective, randomized trial.
(DOI: 10.3171/2011.2.FOCUS10313)

Key Words • endoscopic surgery • intracerebral hemorrhage • minimally invasive surgery • surgical result

Surgical management of ICH is still a matter of controversy with regard to indications, timing, and method. In patients with ICH, conventional craniotomy has a mortality rate of 22%–36%, and 44%–74% of patients who undergo the procedure have poor outcomes.[6,15] Recent reports have shown that the endoscopic evacuation of ICH is safe and effective and may have some advantages over traditional craniotomy.[3,9] However, supporting evidence from controlled trials is lacking, and according to the AHA/ASA Guidelines for the Management of Spontaneous Intracerebral Hemorrhage, the effectiveness of minimally invasive ICH evacuation utilizing the endoscopic method is still uncertain and the technique considered investigational.[5] Therefore, we present our series of cases involving patients with supratentorial ICH who underwent endoscope-assisted hematoma evacuation and discuss case selection, surgical technique, and long-term results.

Abbreviations used in this paper: AHA = American Heart Association; ASA = American Stroke Association; EVD = extraventricular drain; GCS = Glasgow Coma Scale; GOSE = extended Glasgow Outcome Scale; ICH = intracerebral hemorrhage; ICP = intracranial pressure; IVH = intraventricular hemorrhage.

* Drs. Kuo and Chen contributed equally to this work.

Methods

Surgical Indications and Patient Selection

To qualify for inclusion in this study, patients had to have the following: 1) a putaminal ICH with a hematoma volume greater than 30 ml; 2) a thalamic ICH with a hematoma volume greater than 20 ml and IVH with acute hydrocephalus; or 3) a subcortical hemorrhage greater than 30 ml with significant mass effect (midline shift greater than 5 mm and effacement of perimesencephalic cistern) and neurological deterioration. In addition they had to have undergone surgery within 12 hours after ictus for inclusion in this study.

Patients who were younger than 45 years or had no history of hypertension underwent contrast CT and CT angiography to exclude the presence of a vascular lesion or tumor. The study exclusion criteria were ICH caused by tumor, trauma, coagulopathy (prothrombin time > 12.2 seconds, partial thromboplastin time > 35.5 seconds, platelet count < $100 \times 10^3/\mu l$), aneurysm, or arteriovenous malformation. Patients taking antiplatelet or anticoagulation medications as well as those with end-stage renal disease or with Child Class C liver cirrhosis were also excluded. Patients with preoperative GCS scores less than 4 or greater than 13 were excluded. In addition, patients who did not have a follow-up CT scan within 3 days after surgery or were lost for follow-up at 6 months were all excluded in this study.

Surgical Technique, Caveat, and Management of Intraoperative Bleeding

For most putaminal ICHs, we use the transtemporal approach (or the "temporal" approach mentioned by Hsieh et al.[4]). (The "frontal" approach is used only when the frontal route provides the shortest distance between the cortical surface and the hematoma on the preoperative CT scan.) In patients with hemorrhage on the left or dominant side, we use the transcortical corridor through the inferior temporal gyrus. In patients with right- or nondominant-side ICH, we use the corridor that traverses the shortest distance to the hematoma (judging from the preoperative coronal CT scan).

In patients with a thalamic ICH, the goal is to alleviate the acute hydrocephalus and elevated ICP while removing the IVH and ICH as much as possible without causing further damage to the brain parenchyma. Therefore, we use the ipsilateral Kocher point as our entry point. In patients with massive IVH, a flexible endoscope may be used with the free-hand technique to evacuate the blood in the third and fourth ventricles.[5] In addition, bilateral EVD placement may be considered in these cases. If the ventricle is entered during surgery, an EVD will be inserted through the operative tract.

With the patient in a state of general anesthesia, a linear skin incision (3–4 cm in length) is created. A 1.5- to 2.0-cm bur hole is then created with the dura opened in cruciate fashion. A small corticotomy is created, and the custom-made transparent plastic sheath (10 mm in outer diameter; length 5, 7, 9, 12, or 15 cm depending on the length needed estimated from the preoperative CT scan; [Fig. 1]) was inserted along with the stylet. This step can be done under real-time ultrasound guidance (Aloka UST- 5268P-5 neurosurgery bur hole probe, 3.0–7.5 MHz, phased-array sector probe) if that is the surgeon's preference. After removal of the stylet, the 4-mm 0° rod-lens endoscope with irrigation system (18 cm in length; Karl Storz) was introduced into the transparent sheath to provide visualization during hematoma removal. Depending on the surgeon's preference, the surgeon may hold the sheath and the endoscope together in his or her right hand, or the assistant may hold the sheath.

Our concept of hematoma removal is depicted in Fig. 2. In our experience, it is prudent to avoid damaging the brain parenchyma with excessive manipulation of the sheath. This can be accomplished by removing the most distal part of the hematoma first and as the sheath is gradually withdrawn the residual hematoma will be pushed into the tip of the sheath as the brain expands. This is in contrast to the traditional craniotomy method that follows the brain parenchyma–hematoma junction during hematoma evacuation to ensure complete hematoma evacuation. The hematoma is evacuated by manipulating the suction through the working space within the sheath. Alternatively, a flexible endoscope (outer diameter 2.5 mm; Karl Storz) could be introduced into the transparent sheath to facilitate hematoma removal without significant rotation or excessive manipulation of the sheath within the brain parenchyma. Using this technique, large and elliptical putaminal ICHs can be evacuated through the temporal approach (instead of the frontal approach[4]) with a high rate of hematoma evacuation.

In our experience, about 70% of ICHs could be evacuated without an obvious or active bleeder being identified intraoperatively. In these cases, the operation was very straightforward and usually could be done within 60 minutes. However, when bleeding occurs, patience is needed

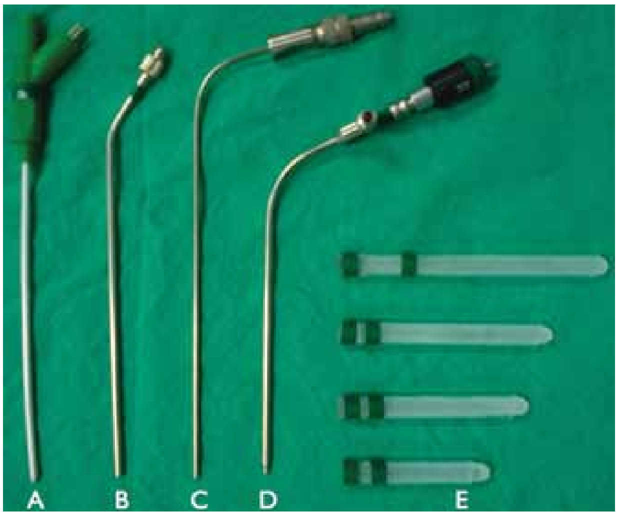

Fig. 1. Instruments used for endoscope-assisted hematoma evacuation. **A:** Bipolar suction coagulator (11 Fr, 14 or 19 cm in length, flexible, disposable; Kirwan Surgical Products). **B:** Specialized 3-mm flexible catheter created to deliver Floseal to the identified bleeder. **C:** Regular angled suction tube (8 Fr). **D:** Unipolar suction-coagulation tube (3 mm, Karl Storz). **E:** Sheaths, 10 mm in outer diameter with various lengths (shown here: 5, 7, 9, and 12 cm).

and some technique must be applied to ensure hemostasis. Bleeding from a small artery or perforating vessel can be secured with repeated irrigation for 2–5 minutes. This is the so-called "wait-and-see saline irrigation" method that is a basic technique of neuroendoscopic surgery. If this does not stop the bleeding, the bleeder must be identified using the balanced irrigation-suction technique, which is elegantly described by Nagasaka et al.[8] With constant irrigation and point suction, the bleeder can usually be identified. The bleeder is then meticulously caught and held by the suction cannula under low-pressure suction. It is then coagulated using a flexible, disposable bipolar suction coagulator (11 Fr, 14 or 19 cm in length; Kirwan Surgical Products; Fig. 1), which performs coagulation and suction simultaneously. The use of hemostatic agents such as Floseal (Baxter) is another alternative. A specialized 3-mm flexible catheter was created to deliver Floseal to the identified bleeder (Fig. 1B). In our series, most bleeding from these perforators stopped after gentle compression with cotton and irrigation for 2 minutes (Fig. 3). After hematoma removal and meticulous hemostasis, we do not insert a drainage tube into the hematoma cavity. An ICP monitor, however, may be inserted as needed.

Clinical and Radiological Follow-Up

All patients underwent a follow-up CT scan within 3 days after surgery. The hematoma evacuation rate in each patient was then calculated as follows: ([preoperative hematoma volume − postoperative hematoma volume]/preoperative hematoma volume) × 100%. Rebleeding, morbidity, and mortality were recorded as primary end points. The GOSE score was recorded at 6-month postoperative follow-up either at an outpatient clinic and/or by telephone survey.

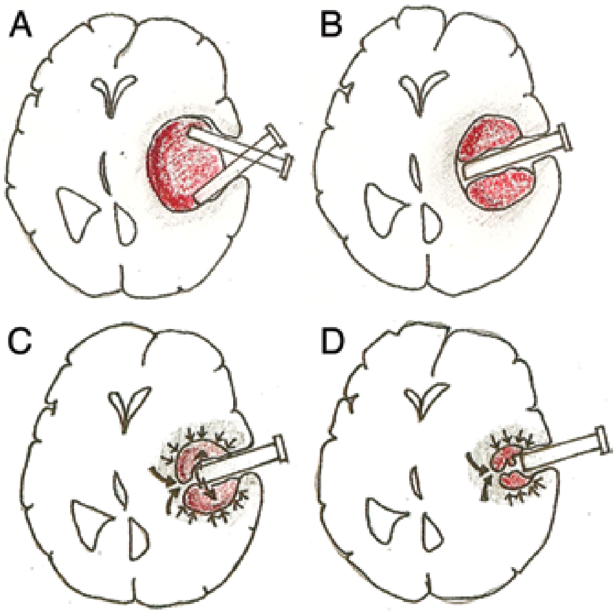

Fig. 2. A: Traditional method of endoscope-assisted ICH evacuation. Hematoma clearance should follow the hematoma–brain junction. Note that the brain is susceptible to damage due to the angle of the sheath. **B:** Our concept of hematoma evacuation, in which suction is directly applied through the long axis of the hematoma until the normal brain surface appears. The depth of the working length can be accurately estimated on preoperative CT scans. **C:** On gradual withdrawal of the sheath, the adjacent residual hematoma is pushed by the expanding brain to the tip of the sheath. The hematoma can be easily and safely evacuated. The angle of the sheath can remain more limited (to avoid damaging the brain). Using this method, the brain tissue injured by the sheath would be significantly less than in the traditional method. **D:** As the sheath is withdrawn, the hematoma cavity collapses and the residual hematoma is pushed into the tip of the sheath.

Results

Between January 2008 and June 2010, 198 patients with ICH were treated at National Taiwan University Hospital Yun-Lin branch and Chang-Hau Christian Hospital. According to the aforementioned inclusion and exclusion criteria, 68 patients who underwent endoscopically assisted ICH evacuation were included in this study. This group included 48 men and 20 women (mean age 63 years, range 42–82 years). There were 35 cases of putaminal ICH (51.5%), 24 cases of thalamic ICH (35.3%), and 9 cases of subcortical ICH (13.2%). All patients underwent surgery within 12 hours of ictus, and 57 patients (84%) underwent surgery within 4 hours. The mean time from ICH onset to surgery was 5.8 hours. The mean operative time was 85 minutes and the average blood loss was 65 ml.

Table 1 summarizes the surgical and functional outcomes in patients with putaminal, thalamic, and subcortical ICH. The hematoma evacuation rate was 93%—96% in the patients with putaminal ICH, 86% in those with thalamic ICH, and 98% in those with subcortical ICH. The mortality rate was 5.9% (4 of 68 patients); 2 patients died of pneumonia and sepsis, 1 died of ischemic bowel and multiorgan failure, and 1 died of cardiogenic shock from suspected acute myocardial injury. Surgery-related morbidity occurred in 3 cases (4.4%): 2 patients had wound infections and 1 had rebleeding. Therefore, the rebleeding rate is 1.5%. The patient with rebleeding was a 62-year-old man with a left putaminal hemorrhage whose GCS score improved gradually after surgery (initial GCS score was 8 and GCS score 1 week after surgery was 13). However, rebleeding occurred 10 days after surgery and his GCS score dropped to 6. The patient underwent repeated surgery using the endoscope-assisted method and his condition improved postoperatively. His GCS score was 12 at 6-month follow-up, but there was no improvement in his right hemiplegia.

In terms of functional recovery, the mean preoperative GCS score was 7.1 and the mean GCS score 1 week after surgery was 11.0. The mean GCS score at 6-month follow-up had improved to 11.6. The mean GOSE score at 6-month follow-up was 4.9.

Discussion

Outcome Improvement With Early and Complete Hematoma Evacuation

Due to the good clinical, radiological, and functional outcomes seen in this series, it is suggested that early and complete evacuation of ICH via a minimally invasive

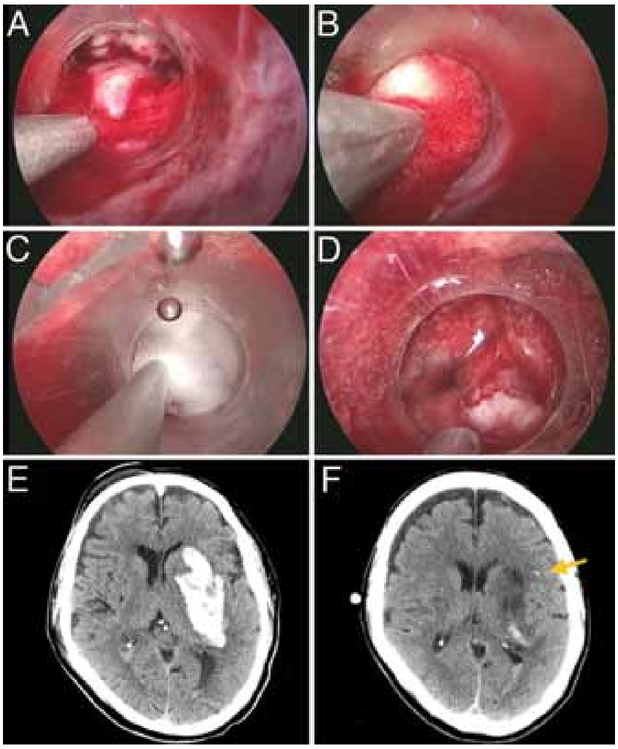

Fig. 3. Using a hemostatic agent in a case of putaminal hemorrhage. **A–D:** Intraoperative images showing the use of the hemostatic agent. The bleeder is identified **(A)** and Floseal is applied to bury and pack the bleeder and adjacent tissue **(B)**. The bleeder is then covered with cotton and gentle pressure is applied with the suction tip while saline irrigation is performed **(C)**. Hemostasis is achieved after 2 minutes **(D)**, and saline irrigation is then used to wash out residual hemostatic agent. **E:** Preoperative axial CT scan showing the left putaminal ICH. **F:** Postoperative CT scan showing 5 ml of residual hematoma and the ICP monitor *(arrow)* that was inserted through the operation tract.

method may lead to improved outcome in these patients. One of the important findings of this study is that early surgery utilizing the endoscope-assisted method has a very low rebleeding rate. Since the hematoma contributes to local mass effect and elevated ICP and elicits pathological cascades that result in biochemical toxicity, it is plausible that early and complete removal of ICH via a minimally invasive method can reduce the secondary injury associated with ICH.[16] Theoretically, this should lead to improved functional outcomes and decreased mortality rates. According to the AHA/ASA Guidelines for the Management of Spontaneous Intracerebral Hemorrhage, no clear evidence at present indicates that ultra-early removal of supratentorial ICH improves functional outcomes or mortality rates. In addition, the authors mentioned that very early craniotomy may be harmful due to increased risk of recurrent bleeding. This recommendation was based on a trial of 11 patients randomized within 4 hours of hemorrhage onset, where rebleeding occurred in 40% of the patients treated within 4 hours compared with 12% of the patients treated within 12 hours using the craniotomy method.[7] On review of the literature, we found that endoscope-assisted ICH evacuation performed in the early stage was associated with a minimal rebleeding rate (0%–3.3%) compared with the traditional craniotomy method (5%–10%).[3,9] However, differences in patient selection, surgical indication, timing, technique, and perioperative care made direct comparison inappropriate and mandate the need for a randomized-controlled study to elucidate this point. Other advantages of the endoscope-assisted method include low complication rate, less operative time, less blood loss, improved evacuation rate, and early recovery of the patients. The results of our study further confirm these potential benefits compared with traditional craniotomy.

Second, endoscope-assisted ICH evacuation may provide a better hematoma evacuation rate with minimal damage to normal brain tissue. Due to the improvement of neuroendoscopic systems and instruments, recent series have shown high rates of hematoma evacuation that

TABLE 1: Surgical and functional outcomes in patients with putaminal, thalamic, or subcortical ICH

Variable	Putaminal ICH	Thalamic ICH	Subcortical ICH	All
no. of patients	35	24	9	68
median hematoma evacuation rate (%)	96	86	98	93
rebleeding rate (%)	2.8	0	0	1.5
morbidity				
no. of patients	2	1	0	3
rate (%)	5.7	4.1	0	4.4
mortality				
no. of patients	1	2	1	4
rate (%)	2.8	8.3	11.1	5.9
mean GCS scores (range)				
preop	7.8 (4–14)	5.8 (4–14)	8.2 (6–12)	7.1 (4–14)
1 wk postop	12.2 (3–15)	8.9 (3–15)	12.1 (3–15)	11.0 (3–15)
6 mos postop	12.8 (3–15)	9.8 (3–15)	11.8 (3–15)	11.6 (3–15)
mean GOSE 6 mos postop (range)	4.8 (1–7)	5.2 (1–7)	4.9 (1–8)	4.9 (1–8)

ranged from 83.4% to 99%.[3,4,8–10,12] The hematoma evacuation rate in the present study is comparable to what has been reported in the literature. We do think that there is a trend toward a higher evacuation rate when the surgery is performed early (within 12 hours) due to the fact that, within this period, the clot is usually easily suctioned (in contrast to the treatment of subacute hematomas). This is in contrary to the common belief that delayed evacuation is technically simpler due to partial liquefaction of the hematoma. However, our experience is further supported by the experience of the authors of another large series who mentioned that "surgery should be performed within 24 hours after onset, because intracerebral hematoma usually starts to harden about 24 hours after onset and 48 hours later it can not be evacuated with a suction tube."[12] The lower evacuation rate in thalamic ICH is a reflection of our different philosophy toward its treatment. Although enthusiasm for surgical evacuation of thalamic ICH has been limited, we do think that relieving the acute hydrocephalus from IVH is necessary for better recovery. As mentioned previously, the IVH and thalamic ICH were evacuated as much as possible without damaging the brain parenchyma. We perform aspiration at the rupture site (Fig. 4), and we do not enter the thalamus in attempt to remove more clot. For this reason, the hematoma clearance rate was lower in patients with thalamic ICH (86%). In addition, patients with thalamic ICH usually recover more slowly than patients with subcortical or putaminal ICH (Table 1).

Comparison With Different Methods of Endoscope-Assisted ICH Evacuation

Several groups have developed methods of minimally invasive endoscope-assisted ICH evacuation.[1,3,4,8–14] Table 2 summarizes the surgical indications, timing, technique, and results of the endoscope-assisted methods of ICH evacuation as reported in different series.

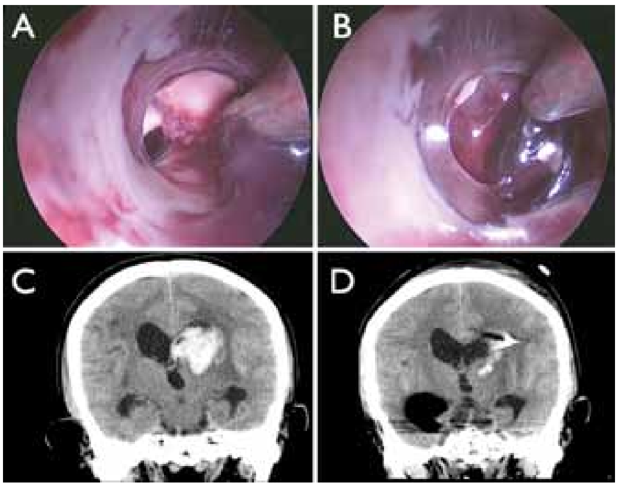

Fig. 4. Endoscope-assisted evacuation of left thalamic ICH and IVH with acute hydrocephalus. **A and B:** Intraoperative images showing evacuation of the IVH **(A)** and ICH **(B).** The IVH was evacuated through the sheath inserted through the ipsilateral Kocher point **(A)**. The ipsilateral foramen of Monro was seen after IVH evacuation. The ICH was evacuated through the rupture site on the thalamus **(B)**. We do not enter the thalamus for more complete hematoma evacuation. **C:** Preoperative coronal CT scan showing the left thalamic ICH and the IVH. **D:** Postoperative CT scan showing some residual hematoma and the EVD that was inserted through the operation tract.

However, it is difficult to directly compare the morbidity, mortality, and functional outcomes due to differences in patient selection, timing of surgery, technique, and perioperative care. Nevertheless, our outcome is comparable with that of other series. The major difference is the concept of hematoma evacuation that is depicted in Fig. 2. This concept of removing the most distal part of the hematoma first and having the residual hematoma collapse into the tip of the sheath decreases the need to stir or damage the brain by changing the angle of the sheath. It also avoids the early collapse of the hematoma cavity with residual hematoma that may need the inflation-deflation method to solve this problem.[8]

The selection of the approach (the frontal or temporal approach) for putaminal ICH is an important issue. Hsieh et al.[4] mentioned that, in patients with ICH volume less than 50 ml, it is not difficult to evacuate the hematoma through the shortest distance from the cortical surface to the hematoma. However, when the hematoma is larger than 50 ml, the shape usually became elliptical. The frontal approach was recommended by the authors in these cases due to its involving noneloquent regions and providing better visualization that may result in maximal hematoma evacuation. Our group used the temporal approach in most cases of putaminal ICH (29 [83%] of 35). The concept of hematoma evacuation was mentioned; it avoids excessive manipulation of the sheath and consequent damage to the brain parenchyma. If needed, flexible endoscopy may be used to evacuate the clot. When a bleeder is identified, the sheath is then pointed toward the bleeder for better visualization and secure hemostasis. The frontal approach may traverse the lenticulostriate perforators that may obscure visualization or even contribute to intraoperative bleeding. This may explain the high incidence of intraoperative bleeding (9 [82%] of 11 cases) in one series in which the frontal approach was used.[10] In our experience using the temporal approach for putaminal ICH, evacuation could be accomplished in approximately 70% of the cases without obvious intraoperative bleeding. The other advantage is the shorter working distance, which increases the comfort of the procedure and facilitates deftness. In cases in which a frontal approach is used, we usually create the bur hole in a more lateral position as mentioned by Suyama et al.[14]

Some authors advise that a posterior approach is better than an anterior approach for evacuating a thalamic hematoma and avoids injury to the intraventricular veins.[2,9,14] Nevertheless, we think that the approach chosen depends upon the extent of hematoma one plans to remove and the rupture site. As mentioned, our goal for these patients is to alleviate the elevated ICP and remove the IVH and ICH without causing further neuronal damage. Therefore, in most of our cases, we have chosen the anterior approach. There was no incidental injury of the venous structure in any of our cases.

With respect to other minor differences, we felt more confident using the suction bipolar coagulator instead of

TABLE 2: Surgical indications, timing, technique, and results of the endoscopically assisted method for ICH evacuation in different series*

Authors & Year	Indication	Timing	Pt Characteristics	Technique	Evacuation Rate	Rebleeding Rate	Long-Term Outcome†
Nishihara et al., 2000	putaminal ICH vol >40 ml	median time to op: 3 hrs (range 1.5–11 hrs)	9 pts w/ putaminal ICH	10-cm-long rigid transparent sheath made of acrylic plastic attached to SS handle w/ round-tipped metal stylet	86%–100%	NA	NA‡
Nakano et al., 2003	hematomas w/ vol >20 ml & <40 ml; putaminal ICH of small-intermediate size, hematoma situated deep in the brain (e.g., thalamic hemorrhage), intraventricular hematoma	NA	7 pts; 4 w/ putaminal ICH, 2 w/ thalamic ICH, & 1 w/ subcortical hemorrhage; avg age 55 yrs	NA	NA	NA	NA§
Suyama et al., 2004	NA	0–14 days	48 pts; 32 w/ putaminal ICH, 9 w/ thalamic ICH, & 7 w/ lobar ICH	transparent sheath, hematoma cavity irrigated w/ artificial CSF	putaminal ICH 82%; thalamic ICH 76%; lobar ICH 82%	2.0%	NA
Nishihara et al., 2005	putaminal, thalamic, & subcortical ICH w/ vol >20 & cerebellar ICH w/ vol >15 ml w/ deterioration of consciousness	ultra-early op (w/in 3 hrs) for hemorrhages w/ vol >30 ml or hemorrhages causing impending herniation	82 pts w/ ICH or IVH; 44 w/ putaminal ICH, 12 w/ thalamic ICH, 8 w/ subcortical ICH, 8 w/ cerebellar ICH, 10 w/ IVH	transparent sheath; hemostasis by electric coagulation at suction end; transparent cap attached to flexible endoscope provides clear visualization of op field during hematoma evacuation, which can prevent injury of ventricular walls	96% (range 86%–100%)	no postop rebleeding	NA
Chen et al., 2005	putaminal ICH vol >20 ml, GCS 5–12 w/ focal neurol deficit	1–5 hrs (median 2 hrs)	7 pts w/ hypertensive putaminal ICH; age range: 45–69 yrs	an 11-cm-long SS tube was adapted to serve as endoscopic sheath; op route along long axis of hematoma, requiring frontal approach	90%–97% (median 93%); ICH vol 20–180 ml (median 78 ml) preop, 2–16 ml (median 6 ml) postop	no postop rebleeding	6 pts were fully independent, including 4 who had no residual disability & 2 who had mod disability; 1 pt remained in a persistent vegetative state at clinical FU after 6 mos
Nagasaka et al., 2010	putaminal ICH vol >31 ml, cerebellar ICH w/ diam >3 cm, or thalamic ICH w/ vol >20 ml & acute hydrocephalus	median time to op: 4 hrs	23 pts; 15 w/ putaminal ICH, 6 w/ cerebellar ICH, 2 w/ thalamic ICH; mean age 61.4 yrs (range 36–85 yrs); mean preop GCS score: 7.2 (range 4–13)	a combination irrigation-coagulation suction cannula or multifunctional suction cannula was used	99%	0%	long-term outcome not mentioned, but the rate of good outcome (good recovery & mod disability) at discharge was 17.3%

(continued)

TABLE 2: Surgical indications, timing, technique, and results of the endoscopically assisted method for ICH evacuation in different series* *(continued)*

Authors & Year	Indication	Timing	Pt Characteristics	Technique	Evacuation Rate	Rebleeding Rate	Long-Term Outcome†
present series	putaminal ICH vol >30 ml, or thalamic ICH vol >20 ml & IVH w/ acute hydrocephalus, or subcortical ICH vol >30 ml w/ sig mass effect & neurol deterioration	all ops performed w/in 12 hrs & 84% of ops performed w/in 4 hrs	68 pts; 35 w/ putaminal ICH, 24 w/ thalamic ICH, & 9 w/ subcortical ICH; mean age 63 yrs (range 42–82 yrs); mean preop GCS score 7.1 (range 4–14)	transparent sheath, balanced irrigation-suction technique for identification of bleeder, coagulation w/ suction bipolar coagulator, hemostasis w/ Floseal; flexible endoscope used as an option	93%; putaminal ICH 96%; thalamic ICH 86%; subcortical ICH 98%	1.5%	mean GCS score was 11.6 & GOSE was 4.9 at 6-mo FU

* avg = average; diam = diameter; FU = follow-up; mod = moderate; NA = information not available; neurol = neurological; Pt = patient; sig = significant; SS = stainless steel.
† At least 6 months postoperatively.
‡ All patients showed neurological improvement when they were examined 1 week after the procedure.
§ Good recovery in 50% of patients, but no details on long-term outcome.

the monopolar coagulator, and we do not place a drainage tube within the hematoma cavity after securing hemostasis. This study also demonstrates that the use of a hemostatic agent for noncoagulation hemostasis seems to be safe because the rebleeding rate was very low.

Study Limitations

We acknowledge the limitation of these preliminary results in this retrospective nonrandomized study. The patients in this study are highly selected and represent 34% of all ICH patients we have cared for in a 30-month period. Patients with a GCS score of 3, surgery after 12 hours from ictus, coagulopathy, or treatment with antiplatelet or anticoagulant therapy were excluded. These patients usually have a poor prognosis compared with the patients included in this study. Therefore, the good surgical outcomes and functional results may be due to patient selection.

Conclusions

The results in our series of 68 patients indicate that early endoscope-assisted ICH evacuation is safe and effective in the management of supratentorial ICH. The rebleeding, morbidity, and mortality rates are low compared with rates reported in the literature for the traditional craniotomy method. This study also showed that early and complete evacuation of ICH may lead to improved outcomes in selected patients. However, these preliminary results warrant further study in a large, prospective, randomized trial in the near future.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Acquisition of data: Kuo, Chen, Chiu, Liu. Analysis and interpretation of data: Huang, Li, Tsai. Drafting the article: Huang, Kuo, Chen, Li, Tsai. Critically revising the article: Huang, Kuo, Chen, Tu. Reviewed final version of the manuscript and approved it for submission: Huang, Kuo, Chen, Tu. Study supervision: Tu.

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Manuscript submitted December 15, 2010.
Accepted February 7, 2011.

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