Frontal bur hole through an eyebrow incision for image-guided endoscopic evacuation of spontaneous intracerebral hemorrhage

Clinical article

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Object. Surgical evacuation of spontaneous intracerebral hemorrhage (sICH) remains a subject of controversy. Minimally invasive techniques for hematoma evacuation have shown a trend toward improved outcomes. The aim of the present study is to describe a minimally invasive alternative for the evacuation of sICH and evaluate its feasibility.

Methods. The authors reviewed records of all patients who underwent endoscopic evacuation of an sICH at the UCLA Medical Center between March 2002 and March 2011. All patients in whom the described technique was used for evacuation of an sICH were included in this series. In this approach an incision is made at the superior margin of the eyebrow, and a bur hole is made in the supraorbital bone lateral to the frontal sinus. Using stereotactic guidance, the surgeon advanced the endoscopic sheath along the long axis of the hematoma and fixed it in place at two specific depths where suction was then applied until 75%–85% of the preoperatively determined hematoma volume was removed. An endoscope’s camera, then introduced through the sheath, was used to assist in hemostasis. Preoperative and postoperative hematoma volumes and reduction in midline shift were calculated and recorded. Admission Glasgow Coma Scale and modified Rankin Scale (mRS) scores were compared with postoperative scores.

Results. Six patients underwent evacuation of an sICH using the eyebrow/bur hole technique. The mean preoperative hematoma volume was 68.9 ml (range 30.2–153.9 ml), whereas the mean postoperative residual hematoma volume was 11.9 ml (range 5.1–24.1 ml) (p = 0.02). The mean percentage of hematoma evacuated was 79.2% (range 49%–92.7%). The mean reduction in midline shift was 57.8% (p < 0.01). The Glasgow Coma Scale score improved in each patient between admission and discharge examination. In 5 of the 6 patients the mRS score improved from admission exam to last follow-up. None of the patients experienced rebleeding.

Conclusions. This minimally invasive technique is a feasible alternative to other means of evacuating sICHs. It is intended for anterior basal ganglia hematomas, which usually have an elongated, ovoid shape. The approach allows for an optimal trajectory to the long axis of the hematoma, making it possible to evacuate the vast majority of the clot with only one pass of the endoscopic sheath, theoretically minimizing the amount of damage to normal brain.

key WORDS • spontaneous intracerebral hemorrhage • eyebrow incision • endoscopic evacuation • minimally invasive surgery • vascular disorders • diagnostic and operative techniques

SPONTANEOUS intracerebral hemorrhage is a growing health concern whose incidence is 10–30 cases per 100,000 people worldwide. In the US alone, approximately 67,000 people are affected by sICH each year, and this number is expected to double over the next 40 years as the population continues to age. The lifetime cost of sICH per patient is estimated to be $123,565.

Abbreviations used in this paper: GCS = Glasgow Coma Scale; MLS = midline shift; mRS = modified Rankin Scale; sICH = spontaneous intracerebral hemorrhage.

Recognized risk factors for sICH include male gender, increasing age, hypertension, and being Hispanic or African American.

There is no agreed-upon treatment strategy for sICH, and surgical intervention remains a matter of debate. A meta-analysis of 18 randomized prospective studies published between 1960 and 2010 on the topic of surgical versus medical treatment for supratentorial sICH concluded that there was no significant difference in morbidity or mortality rate between the 2 treatment options. However, subgroup analysis did show that surgical outcomes were significantly improved compared with those
following medical management, in patients with hematoma volumes greater than 40 ml, patients who underwent surgery within 24 hours of presentation, and patients with an initial GCS score of 6 or greater.

The failure of open craniotomy to improve the outcomes of patients with sICH has led to the development of minimally invasive techniques. Studies involving these techniques have shown a trend toward improved outcomes compared with outcomes after medical management. 

The goal of the present article is to describe a minimally invasive alternative for image-guided endoscopic evacuation of sICH, one involving the anterior basal ganglia, through an eyebrow incision and frontal bur hole. The secondary aim is to evaluate the feasibility of this technique.

Methods

We reviewed records of all 41 patients who underwent endoscopic evacuation of an sICH at the UCLA Medical Center between March 2002 and March 2011. All patients who underwent the eyebrow incision/frontal bur hole technique whose bleeds were not associated with arteriovenous malformation, aneurysms, trauma, tumor, cavernous malformations, or hemorrhagic conversion of cerebral infarction were included in this series. The study was approved by the UCLA Institutional Review Board.

Patients were chosen for the eyebrow incision and frontal bur hole approach based on the location and shape of the hemorrhage. The approach is intended for anteriorly located basal ganglia hemorrhages, which tend to have an elongated, ovoid shape.

Each patient was initially admitted to the neurosurgical ICU and treated conservatively. Systolic blood pressure was maintained at between 100 and 140 mm Hg, and patients were not taken to the operating room until their International Normalized Ratio was less than 1.3 and their platelet count was greater than 100,000. Any patient on antplatelet therapy at the time of admission was given 1 U of platelets and 0.3 mg/kg of desmopressin prior to surgery. Two CT studies, separated by at least 4 hours, were obtained in each patient to confirm the absence of early clot expansion. This stability scan study includes a thin-cut CT scan obtained with and without contrast, which was used both to rule out a vascular malformation, and for intraoperative neuronavigation. Ongoing hematoma expansion, coagulopathy, or an underlying vascular malformation is a contraindication for this technique.

Operative Technique

The patient is positioned supine with the head fixed in a Mayfield head holder. The cranial landmarks are registered to the preoperative thin-cut CT scan to enable the use of the frameless stereotactic neuronavigation system. This system is then used to identify the appropriate entry point and trajectory to enter the hematoma. For each patient in this series a frontal approach was selected with the entry point in the supraorbital bone just lateral to the frontal sinus (Fig. 1).

A 3.5-cm incision is made at the superior margin of the eyebrow. The frontalis muscle is divided, and a 16- to 18-mm-diameter bur hole is made in the supraorbital bone just lateral to the frontal sinus, which is localized using the navigation system. The dura mater is coagulated and incised, and a small corticectomy is made. Using frameless stereotactic guidance, the 8-mm Frazee neuroendoscope (KARL STORZ Endoscopy-America, Inc.), with the obturator in place, is advanced to a depth two-thirds of the way along the long axis of the hematoma. This is the first of two prespecified sites where suction is applied. The endoscopic sheath is held securely in place using a Mitaka robotic arm (Mitaka Optical Co., Ltd). The obturator is then removed and the endoscopic sheath is attached to suction. We use regulated wall suction, beginning at 50 torr and increasing incrementally by 50 torr until the hematoma begins to evacuate. In our experience, using the 8-mm sheath, the safest and most effective pressure is between 100 and 200 torr. Once no more hematoma can be easily evacuated, the endoscope sheath is pulled back to a depth one-third of the way along the long axis of the hematoma, and the process is repeated (Fig. 2). The hematoma is collected and its volume is measured in a Luken trap before it is sent to pathology (Fig. 3). Once 75%–85% of the preoperatively determined volume of the hemorrhage has been collected, and no more hematoma fluid is easily evacuated, suction is suspended. The endoscope’s camera is inserted and used to assist in and confirm hemostasis. It is important to note that endoscopic visualization is not used before this point. Hemostasis is achieved by continuous irrigation with the camera in place. For platelet activation, one dose of intravenous desmopressin at 0.3 μg/kg is useful to help stop persistent bleeding. Endoscopic cautery is rarely needed for active bleeding. Next, the endoscopic sheath is removed with the camera in place to inspect the walls of the endoscope tract for bleeding. A collagen sponge is placed to the cortic-
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A titanium bur hole cover is placed over the skull defect and the wound is closed in layers. A running subcuticular stitch is used to close the skin and is reinforced with Dermabond Advanced (Ethicon Inc., Johnson & Johnson). No dressing is necessary.

**Imaging Evaluation**

Postoperative CT scanning is performed to determine if the hematoma has been adequately evacuated, either immediately in the operating room (with a portable CT scanner) or within 1 hour of surgery in the radiology suite. A CT or MRI scan is obtained on postoperative Days 1, 7, and as needed to monitor for rebleeding. Hematoma volumes were calculated using the following formula: \(\text{volume} = \frac{\text{length} \times \text{width} \times \text{height}}{2}\) (Fig. 4).\(^{15}\) The MLS was calculated by drawing a line between the most anterior and posterior portions of the falx cerebri and measuring the maximum deviation of the septum pellucidum from this line, at the level of the lateral ventricles. All measurements were calculated using the last CT scan before surgery and the first CT scan after surgery. The preoperative and postoperative CT scans for each of the patients in this study are shown in Fig. 5.

**Clinical Evaluation**

History and neurological examinations were performed in each patient by the on-call neurosurgery resident at the time of admission. Initial neurological status was assessed using the GCS and mRS based on the admission examination.\(^{25,27}\) Postoperative neurological sta-

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**Fig. 2.** The stereotactic guidance system was used to plan and perform the endoscopic evacuation. Suction point No. 1 is two-thirds of the way along the long axis of the hematoma (A), and Suction point No. 2 is one-third of the way along the long axis of the hematoma (B).

**Fig. 3.** The surgeon is able to control the amount of suction applied to the hematoma by placing a thumb over the end of the endoscopic sheath, which is held in place by a hydraulic arm.

**Fig. 4.** Hematoma volumes are calculated using the formula: volume = \((A \times B \times C)/2\).
tus was assessed by GCS score at the time of discharge and by mRS score at the time of last follow-up. Discharge examinations were performed by a member of the inpatient neurosurgery team, either a resident or nurse practitioner. Follow-up examinations were performed by either the neurosurgery faculty member or a nurse practitioner in the clinic. Intracerebral hemorrhage scores (ICH score) were recorded based on the admission examination. Clinical scores were calculated based on review of patient records by the investigators.

Statistical Analysis

The mean reduction in hematoma volumes and MLS were calculated and recorded. Admission GCS scores were compared with discharge GCS scores, and admission mRS scores were compared with last follow-up mRS scores. A paired t-test was used to compare preoperative hematoma volumes and MLS with postoperative values. Statistical significance was set at $p < 0.05$.

Results

Six patients, whose average age was 59 years (range 38–91 years), met the inclusion criteria and were included in the study. The average time from presentation to surgery was 17 hours and 56 minutes. Table 1 summarizes the clinical information for the patients in this study.

**Imaging Results**

None of the preoperative stability scans showed any measurable hematoma expansion. Furthermore, there was no evidence of a “spot sign” on any of the preoperative CT angiograms. Initial postoperative CT scans showed that the goal of at least 75% reduction in hematoma volume was achieved in 5 of the 6 patients. One patient presented with a relatively small hematoma volume (30.2 ml). A postoperative CT scan showed a 49% reduction in the hematoma volume (15.4 ml).

The mean pre- and postoperative hematoma volumes were 68.9 ml (range 30.2–153.9 ml) and 11.9 ml (range 5.1–24.1 ml), respectively, for an average reduction in hematoma volume of 79.2% (range 49%–92.7%) ($p = 0.02$). The mean pre- and postoperative MLS distances were 7 mm (range 1.7–9.1 mm) and 3 mm (range 0.7–6.5 mm), respectively, for an average reduction of 57.8% (range 28.6%–76.7%) ($p < 0.01$). Computed tomography scans obtained on postoperative Days 1, 7, and as needed did not show rebleeding in any of the patients. The imaging variables are shown in Table 2.

**Clinical Results**

In each patient an improvement from admission GCS score to discharge GCS score was exhibited. The median admission GCS score was 7.5 (range 6–9), and the median discharge GCS score was 10.5 (range 8–14). In 5 of the 6 patients we noted improvement in mRS scores from the time of admission to last follow-up. All patients had

**TABLE 1: Clinical information obtained in patients who underwent sICH evacuation**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>ICH Location</th>
<th>Time From Presentation to Op (hrs:mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52</td>
<td>lt basal ganglia</td>
<td>7:52</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>rt basal ganglia</td>
<td>13:57</td>
</tr>
<tr>
<td>3</td>
<td>91</td>
<td>lt basal ganglia</td>
<td>19:00</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>rt basal ganglia</td>
<td>21:19</td>
</tr>
<tr>
<td>5</td>
<td>66</td>
<td>lt basal ganglia</td>
<td>11:36</td>
</tr>
<tr>
<td>6</td>
<td>57</td>
<td>lt basal ganglia</td>
<td>33:50</td>
</tr>
<tr>
<td>mean</td>
<td>59</td>
<td></td>
<td>17:56</td>
</tr>
</tbody>
</table>
an admission mRS of 5. The median mRS at the time of last follow-up was 3.5 (range 1–6). One patient, with a large left basal ganglia hemorrhage, died 2 weeks after surgery after being placed on comfort care at the request of the family. The median ICH Score for all patients was 3 (range 2–4). The average length of stay in the hospital was 20.8 days (range 9–52). The average follow-up was 20.8 months (range 0.5–65). The clinical results are presented in Table 3.

Discussion

Surgery for sICH remains a controversial topic. Studies to date have not shown a clear benefit for surgical intervention over the best medical management. However, studies involving minimally invasive techniques for sICH evacuation have shown a trend toward improved outcomes compared with medical management alone.

A wide range of minimally invasive techniques for sICH removal currently exists. In 2005 Vespa et al. published a study describing frameless stereotactic catheter aspiration with the use of tissue plasminogen activator. In their study of 28 patients, the authors reported a mean reduction of hematoma volume of 77% ± 13% and a significant improvement in NIH Stroke Scale score at discharge compared with the initial score. While this strategy can be used at the bedside in the ICU, thereby avoiding the risks of general anesthesia, complete clot evacuation is a gradual process that may take days compared with the immediate evacuation of endoscopic or microsurgical approaches.

Image-guided keyhole evacuation, using microsurgical techniques, has been described by multiple authors. Barlas et al. reported an average reduction in hematoma volume of 97.5% (range 92.9%–100%), and they demonstrated significant improvements in both radiological and clinical data. Microsurgical evacuation has the advantage of immediate and near-complete hematoma removal, but it does require more cortical exposure and brain retraction than endoscopic techniques.

Image-guided endoscopic evacuation of an sICH is not a new technique. In 1989, Auer et al. published a randomized study including 100 patients with sICH. This was a controlled trial in which the authors compared 50 who patients underwent ultrasound-guided endoscopic evacuation with 50 patients who received conservative management. The results of the study supported endoscopic evacuation, with the surgery-treated group having a significantly lower mortality rate compared with the medically treated group (30% vs 70%, respectively). A study published in 2006 by Cho et al. compared craniotomy, stereotactic aspiration, and endoscopic surgery in 90 patients evenly distributed among the 3 groups. The investigators concluded that stereotactic aspiration and endoscopic surgery are both effective procedures with low complication and mortality rates. However, the delayed evacuation times associated with stereotactic aspiration meant this technique was at a disadvantage compared with endoscopic surgery.

The supraorbital approach via an eyebrow incision has been used for many years for various intracranial pathological entities. In 1998 van Lindert et al. described a supraorbital approach through an eyebrow incision for the treatment of intracranial aneurysms. Reisch and Pernezky recently published their 10-year experience with this approach for aneurysms, extra- and intraaxial tumors, sellar and suprasellar tumors, cystic lesions, arteriovenous malformations, and cavernomas for a total of 450 cases. However, to our knowledge, the present study is the first report of using a frontal bur hole through an eyebrow incision for image-guided endoscopic evacuation of an sICH.

In the present article we have described a minimally invasive alternative for image-guided endoscopic evacuation of sICH and evaluated its feasibility. Imaging results showed a mean reduction in hematoma volume (79.2%), which is similar to previously reported results for endoscopic evacuation. We also demonstrated a reduction in MLS. While rebleeding is a concern in minimally invasive hematoma evacuation, imaging revealed no episodes of recurrent of bleeding after surgery in our patients. It is important to note that in each case stability of the hematoma size was demonstrated with a repeat CT scanning, including a vascular study, prior to surgery. The soonest any patient proceeded to surgery was approximately 8 hours after presentation. Any evidence of early hematoma expansion or underlying vascular malformation would exclude the patient from undergoing the procedure.

Clinically, the patients in the present series exhibited a trend toward improvement, with GCS scores improving in all patient and mRS scores improving in 5 of 6 patients. The one patient who died in this series had a large, left basal ganglia hemorrhage that left him with global aphasia. Although his GCS score improved to 10 after surgery, his

### Table 2: Summary of imaging results

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Hematoma Vol (mm)</th>
<th>Percentage of Clot Evacuated</th>
<th>MLS (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preop</td>
<td>Postop</td>
<td>Preop</td>
</tr>
<tr>
<td>1</td>
<td>153.9</td>
<td>24.1</td>
<td>84.3</td>
</tr>
<tr>
<td>2</td>
<td>53.9</td>
<td>7.1</td>
<td>86.2</td>
</tr>
<tr>
<td>3</td>
<td>49.5</td>
<td>12.3</td>
<td>75.2</td>
</tr>
<tr>
<td>4</td>
<td>30.2</td>
<td>15.4</td>
<td>49</td>
</tr>
<tr>
<td>5</td>
<td>55.4</td>
<td>7.1</td>
<td>87.2</td>
</tr>
<tr>
<td>6</td>
<td>70.2</td>
<td>5.1</td>
<td>92.7</td>
</tr>
<tr>
<td>mean</td>
<td>68.9</td>
<td>11.9</td>
<td>79.2</td>
</tr>
</tbody>
</table>

* FU = follow-up.

### Table 3: Clinical results for the patients in this series

<table>
<thead>
<tr>
<th>Case No.</th>
<th>GCS Score</th>
<th>mRS Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Admission</td>
<td>Discharge</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

* FU = follow-up.
family elected that he receive comfort care measures only. The mortality rate of 16.7% is much better than the expected 30-day mortality rate of 72% predicted by the median ICH score21 of 3 (range 2–4) for this series of patients.

In our overall experience with sICHs in multiple locations, we have found that evacuating the vast majority of the hematoma endoscopically becomes difficult when hemorrhage volume is less than 30 ml, as demonstrated in our Case 4. However, the decision to take these patients to the operating room is not based on hematoma size. Instead, it is based on physical examination findings of severe focal deficits that correlate with the hematoma location, as was demonstrated in each patient in this study.

A patient population of 6 is not a large enough to prove the safety of the technique. However, during the period reviewed, this same principle of image-guided endoscopic sICH evacuation was employed at UCLA in 41 patients in whom different approaches were used to hematomas in different locations. In this larger series we have achieved an average reduction in hematoma volume of 67.6%, and only 2 patients (5%) experienced rebleeding within 30 days of surgery. Other endoscopic approaches used at our institution include the middle frontal gyrus approach, which uses a bur hole over the coronal suture for anterior basal ganglia hemorrhages that are not elongated but rather are more spherical. A parietooccipital bur hole is created to treat posterior basal ganglia and thalamic hemorrhages. In cases involving superficial lobar hemorrhages, we commonly use a bur hole directly over the hematoma at the location where the lesion comes closest to the surface (Fig. 6).

For each of these different approaches the overall technique remains the same, using image guidance and 2 specific points of suction. Combining the best starting point and trajectory gives the surgeon access to the long axis of the hematoma and subsequently the best chance at maximum evacuation with only a single pass of the endoscope.

In the evolution of this technique we have moved away from visually directed endoscope manipulation for hematoma evacuation. The current technique is directed almost entirely by stereotactic image guidance based on preoperative imaging. The endoscopic camera is only inserted once the hematoma has been evacuated. It is then used during continuous irrigation to monitor for hemostasis. Once adequate hemostasis is observed, the endoscopic camera and sheath are slowly withdrawn together and the camera is used to evaluate for hemostasis of the endoscope tract (Fig. 7). Rarely, one encounters active bleeding that does not stop with continuous irrigation or intravenous desmopressin, in which case endoscopic mono- or bipolar cautery is inserted for direct coagulation. In the present series all patients received an intraoperative dose of desmopressin and one patient required the use of bipolar cautery.

This retrospective review includes only a small case series, and there is no control for other surgical techniques or a comparison with conservative management. A large prospective study is needed to draw any conclusions regarding improved outcomes compared with best medical management or other surgical interventions.

Conclusions

The aforementioned technique appears to be a feasible alternative for treating sICH. It is intended for anteriorly positioned basal ganglia hemorrhages, which commonly have an elongated, ovoid shape. The trajectory afforded by this approach gives access to the long axis of the hematoma, allowing the surgeon to evacuate the vast majority of the hematoma with minimal manipulation of the endoscope, theoretically reducing the amount of injury to the surrounding brain.

Disclosure

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Author contributions to the study and manuscript preparation include the following. Conception and design: Martin, Dye, Lee, Gonzalez. Acquisition of data: Martin, Dye, Dusick, Lee. Analysis and interpretation of data: Dye, Dusick. Drafting the article: Dye, Dusick, Lee. Critically revising the article: Martin, Dusick, Gonzalez. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Martin. Statistical analysis: Dye, Dusick. Administrative/technical/ material support: Martin, Gonzalez. Study supervision: Martin, Gonzalez.

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