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Neuroendoscope-assisted evacuation of large intracerebral hematomas: introduction of a new, minimally invasive technique

Preliminary report

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Object. The aim of this study was to describe a new, minimally invasive technique for the endoscopic evacuation of intracerebral hematomas (ICHs) and the clinical and radiological outcomes in patients who underwent the procedure. The authors used a multifunctional three-in-one endoscopic instrument that combines a 0˚, 4-mm rigid telescope, an irrigation cannula, and a cautery electrode.

Methods. In 13 patients a small keyhole craniotomy was made through noneloquent cortex to gain access to the hematoma. After opening the dura mater, a small cortical tunnel (~6 mm in diameter) was created using bipolar forceps and suction to enter into the clot. The three-in-one endoscope was then introduced to provide illumination and irrigation inside the cavity. The clot was safely aspirated under endoscopic vision and constant irrigation by performing microsurgical suction with the other hand. Hemostasis could be achieved using electrocautery and Surgicel. This technique eliminates the use of an endoscopic sheath, thus providing more maneuverability to the neurosurgeon. The brilliant illumination provided by the endoscope and the possibility of using electrocautery in the depths of the brain combined with the increased maneuverability make this technique valuable. Near-complete hematoma evacuation was achieved in 11 (85%) of 13 patients. There were four deaths (30%).

Conclusions. Safe and effective evacuation of large ICHs is possible by using the three-in-one endoscopic device. Appropriate indications for surgery in patients with large intracerebral hemorrhage must be developed.

KEY WORDS • intracerebral hemorrhage • hematoma • surgery • endoscopy

Surgical evacuation of large spontaneous ICHs intuitively appeals to many neurosurgeons who routinely remove mass lesions from the brain (tumors, contusions, and subdural effusions). Convincing evidence that evacuation of these lesions leads to a better outcome in patients is lacking, however, despite many clinical trials.[4] In a metaanalysis, Prasad, et al.,[15] compared data from four rigorously conducted trials and concluded that researchers in only one trial demonstrated statistically significant improved outcome for patients.

Many endoscopic techniques for the evacuation of ICHs have been described in the literature.[2,12,16] Nonetheless, most neurosurgeons remain hesitant to perform these evacuations routinely, mainly given the absence of clear guidelines, but also because of inadequate control while performing the surgical procedure through traditional endoscopes. The need to control bleeding in the depths of the brain while working through long narrow channels coupled with the difficulties of handling multiple instruments and inadequate illumination in a blood-filled cavity have been formidable challenges. Here we describe a new surgical technique involving the use of a modified neuroendoscope, which overcomes some of these problems and thus gives neurosurgeons more control during the procedure.

CLINICAL MATERIAL AND METHODS

Endoscopic Instrumentation

Recently we developed and described novel multifunctional endoscopic instrumentation.[3] Briefly, this system consists of a fine irrigation catheter and an insulated electrode directly attached to a 4-mm, 0˚ rigid Hopkins telescope with the aid of small pieces of shunt tubing (Fig. 1). This modification converts an optical device (telescope) into a surgical instrument that can be used as a microdissector deep in the brain, an electrosurgical instrument, and an irrigation device. All of these capabilities are concentrated in a single hand-held three-in-one device, leaving the surgeon's other hand free to manipulate a suction catheter or a bipolar forceps. As a result of this combination, views such as those featured in Fig. 2a can be obtained intraoperatively.

During ICH surgery, the three-in-one device is used directly, with no outer sheath or preformed channels, which

Abbreviations used in this paper: CT = computerized tomography; ICH = intracerebral hematoma; ICU = intensive care unit.

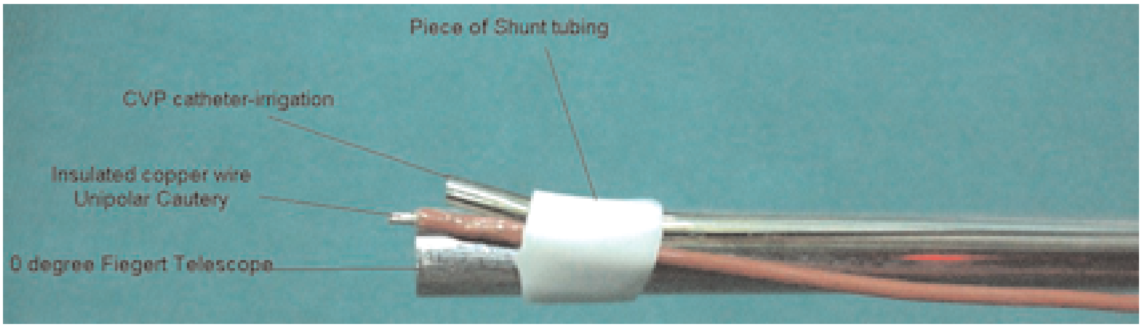

Fig. 1. Photograph depicting the three-in-one device that combines a 0°, 4-mm rigid endoscope, an insulated copper wire used as an electrocautery electrode, and a central venous pressure (CVP) cannula used for irrigation. All three devices are held together with small pieces of shunt tubing.

are common features of most neuroendoscopic systems available at present. Additional advantages of these modifications include an automatic alignment of the cautery electrode and the irrigation cannula with the visual axis so that the entire assembly moves together.

Patient Population

Thirteen patients participated in this study. Inclusion criteria consisted of the following: large clots (volume > 40 ml); known origin of hypertension; clots located in the thalamus, putamen, or capsular regions; and worsening neurological status despite aggressive measures to control intracranial pressure. Patients with the following characteristics were excluded from this study: small clots (volume < 40 ml); conscious state; improved neurological status with conservative therapy; infratentorial or atypical location of supratentorial clot; no clinical evidence or history of hypertension; exact ICH origin in doubt, that is, suspected aneurysm, arteriovenous malformation, bleeding diathesis, or trauma; deeply comatose patient with Glasgow Coma Scale score of less than 5; a history of unconsciousness lasting longer than 72 hours.

At the time of hospital admission, all patients received aggressive therapy to control their intracranial pressure, including full-dose decongestants (mannitol and frusemide), elective hyperventilation, head elevation, and elimination of neck vein compression along with appropriate control of hypertension. Serial CT scans were obtained, and periodic clinical examinations were conducted to ascertain the neurological and radiological status of each patient. Blood investigations were performed to exclude a bleeding disorder. All patients whose neurological status

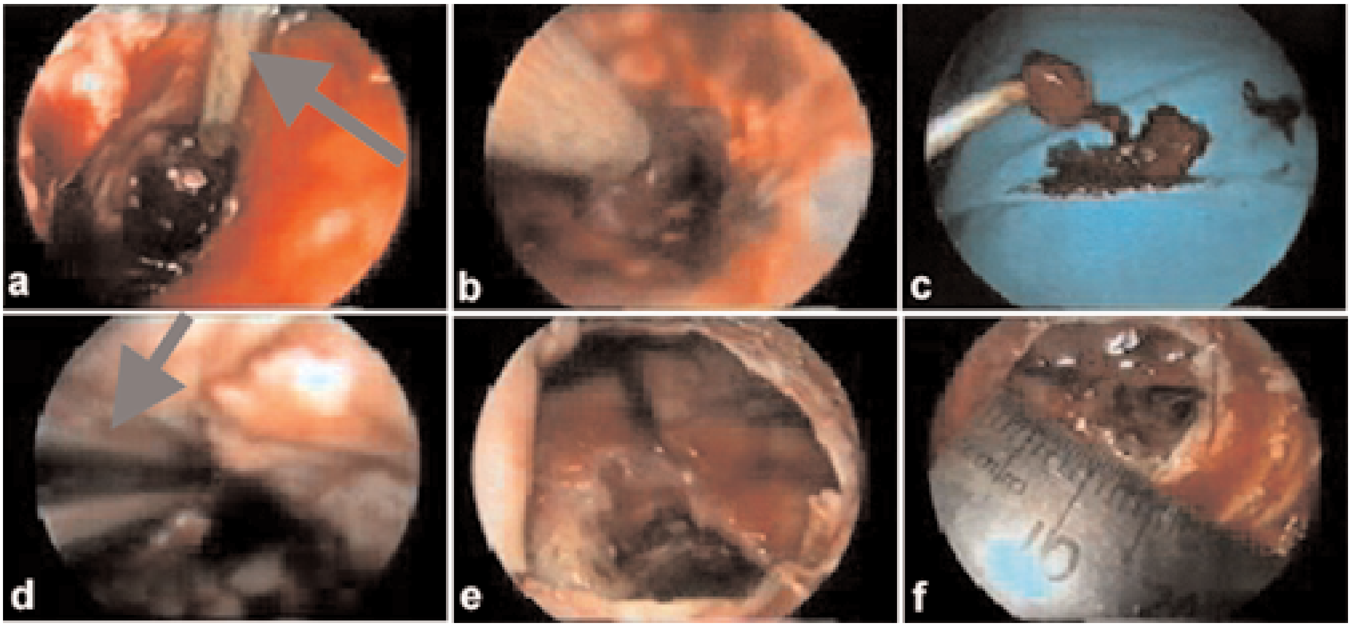

Fig. 2. Photographs depicting the neurosurgeon's intraoperative views during the ICH evacuation. a: The suction tip *(arrow)*, which is kept within the endoscopic field of vision at all times, is used to break the clot. b and c: Large chunks of clot can be broken and suctioned out. d: A bipolar forceps *(arrow)* can be introduced into the hematoma cavity for placing cotton patties or Surgicel, making hemostasis much easier. e: The brain is relaxed by the end of the procedure and has fallen away from the dura mater. f: Craniotomy size is limited to 15 mm in diameter and cortical incision is approximately 6 mm in diameter.

continued to deteriorate even 12 hours after the administration of conservative therapy were considered for surgery. Their families were counseled and surgical evacuation of the ICH was offered as a life-saving maneuver. It was clearly explained that there was very little likelihood of improvement in hemiparesis or dysphasia in cases in which these were already present and that the patient was likely to have a difficult postoperative course and major disabilities even if they had survived surgery.

All surgeries were performed at the Vidyasagar Institute of Mental Health and Neurosciences, New Delhi, between June 2000 and March 2003.

Surgical Technique

All surgical procedures were performed with the patient in a state of general anesthesia. We have attached a video clip that demonstrates the steps described hereafter.

Click here to view Video Clip 1. The video clip shows the steps of the procedure described in the text. The clot can be seen as it is aspirated by the suction apparatus under endoscopic vision. Next, the empty clot cavity is seen. Finally, the lax brain is seen as it has fallen away from the dura, and the small cortical incision is appreciated against the scale.

Craniotomy. Considerable effort was made to locate the craniotomy in the most appropriate portion of the skull and the parameters considered important included the shortest trajectory to the clot, a trajectory passing through noneloquent regions of the cortex, and alignment of the cavity along the long axis of the clot. After careful radiological evaluation that incorporated these factors, most craniotomies were localized in the frontal bone, on or anterior to the coronal suture, at least 2 cm from the sagittal suture. The laterality of the craniotomy depended on the lateral extension of the clot. All procedures were performed through a 15-mm-diameter trephine craniotomy. This size was carefully chosen as a compromise between minimal invasiveness and adequate access for the neurosurgeon.

Clot Entry. A single, linear, 4-cm-long, mediolateral scalp incision over the craniotomy site was found to be adequate, allowing for rapid opening and closure. The trephine craniotomy was elevated and the dura mater was opened as a U-shaped flap. The brain was extremely tense in all cases, invariably bulging out of the craniotomy. Rapid coagulation of the pia mater followed by suction in the direction of the clot allowed entry into the hematoma cavity. This initial portion of the surgery was accomplished with the aid of head-light illumination. Emphasis was placed on speed and rapid entry into the clot to achieve a quick decompression of at least some of the clot. The direction of the cortical tunnel was based on results of radiological studies, which indicated the location of the clot and determined the location of the craniotomy. We attempted to keep the size of the cortical tunnel to less than 6 mm, which would allow access for the three-in-one device as well as suction for the next stage of the surgery.

Clot Evacuation. Once the clot had been entered, the three-in-one device held in the right hand and a suction device held in the left hand were introduced into the cavity. All further procedures were performed with the aid of endoscopic vision and constant irrigation. The suction tip, which was used to break up the solid clot, was always kept within the endoscopic field of vision. The smaller and larger clot pieces were sucked out, as shown in Fig. 2b and c. All dissections were performed within the clot cavity, and whenever the clot–brain interface was visualized, it was fastidiously avoided. A 30° telescope proved to be useful to explore the portions of the hematoma that lay away from the line of vision of the 0° telescope. The progress of the surgical evacuation was also monitored by keeping an eye on the distance between the surrounding brain cortex and the dura (Fig. 2e). Once satisfactory decompression had been achieved, the brain invariably relaxed. No attempt was made to perform complete clot evacuation, although near-complete clot evacuation, as shown in Fig. 3, was achieved in 85% of cases. The end point of the evacuation was reached when no more of the clot could be evacuated safely and when the brain had become sufficiently relaxed. Hemostasis was then achieved by irrigation. It was possible to navigate long, narrow cotton patties under endoscopic vision into the clot cavity by using bipolar forceps, as shown in Fig. 2d. A few cases required the placement of small pieces of Surgicel to control small bleeding capillaries. Finally, when copious irrigation of the clot cavity with saline confirmed adequate hemostasis, all instruments were withdrawn the and dura mater was closed. Bone was replaced and the scalp was closed in two layers. All patients continued to undergo elective ventilation, and postoperative CT scans were obtained 12 hours after surgery.

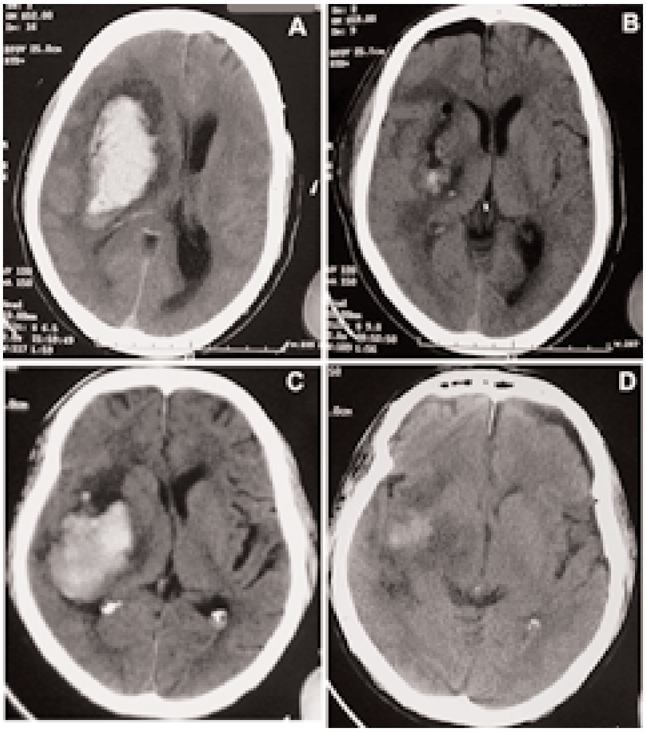

Fig. 3. Preoperative CT scans (A and C) obtained in two different patients together with their respective postoperative scans (B and D). Note the clean hematoma cavity, reduction of midline shift, and presence of subdural air signifying relaxed brain.

RESULTS

Surgical Outcome

All surgeries were completed satisfactorily, with adequate brain relaxation and good hemostasis (Fig. 2e). The craniotomy in all patients was 15 mm and the cortical incision in most patients was approximately 6 mm in size (Fig. 2f). Entering the clot was not a problem in any patient, and careful evaluation of the radiographic studies allowed appropriate craniotomy placement and trajectory determination. Only three patients required bipolar instrumentation of the cavity for control of persistent capillary ooze from the hematoma bed; in all three cases, gentle pressure with cotton patties and small pieces of Surgicel sufficed to achieve hemostasis. In the other 10 patients, hemostasis was achieved using gentle irrigation of the cavity under endoscopic vision. Most of the clot cavity was easily visualized through the 0˚ telescope because of the fish-eye effect visual effect achieved during endoscopy.[14] Only two patients required introduction of the 30˚ telescope to visualize inaccessible portions of the clot.

Radiological Outcomes

Preoperative and postoperative CT scans were compared to determine radiological outcomes. Parameters evaluated included clot volume, midline shift, presence of subdural air in the frontal lobe indicating brain laxity, and appearance of new clots at other locations. The results of this analysis are summarized in Table 1. Satisfactory clot evacuation was possible in all patients as judged by a reduction in midline shift. Example CT scans (Fig. 3) obtained in two patients feature the results of nearly complete evacuation. In one case, a significant amount of the clot remained (Fig. 4), this result was deemed to be adequate decompression based on the reduced midline shift. In another case, the hematoma evolved into a much larger lesion while the patient was undergoing conservative therapy. This patient's condition started to deteriorate neurologically, thus necessitating surgical evacuation of the clot 72 hours after initial ictus. He eventually made a good recovery. All patients had subdural air in the frontal region, signifying adequate brain relaxation subsequent to the surgery.

TABLE 1
Radiological assessment of 13 patients with ICH

Variable	No. of Patients (%)
clot size	
>80% reduction in vol after surgery	11 (85)
<80% reduction in vol after surgery	2 (15)
midline shift	
return to normal	12 (92)
present but less than preop	1 (8)
same or more than preop	0 (0)
subdural air in ipsilat frontal region	
present	13 (100)
absent	0 (0)
new clots	
present	0 (0)
absent	13 (100)

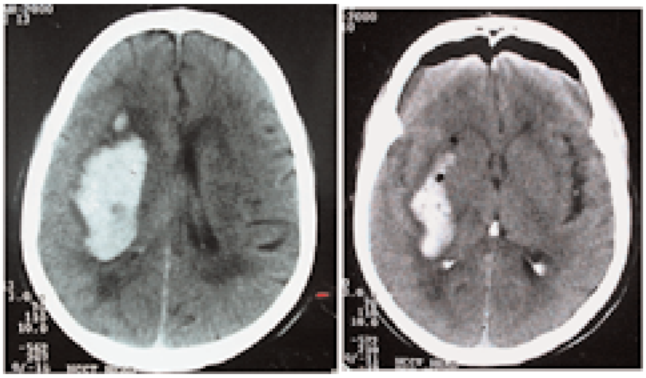

Fig. 4. Preoperative *(left)* and postoperative *(right)* CT scans obtained in a patient with incomplete hematoma evacuation. Note the significant reduction in the midline shift as well as the brain relaxation.

Clinical Outcomes

All patients had a stormy postoperative course in the ICU. There were four deaths (30%), all of which occurred between 3 and 10 days after surgery. Three of the patients who died had experienced an improvement in neurological status postoperatively but suffered from multisystemic problems including cardiac failure, renal failure, and pulmonary edema. One of the patients who died had an intraventricular extension of the hypertensive bleed. This patient did not have an improved neurological status postoperatively despite adequate clot evacuation. Even the patients who survived had a prolonged stay in the ICU and needed multiple medical, cardiac, and pulmonary consultations before they could be discharged from the ICU. Furthermore, all surviving patients had persistent hemiplegia at the time of discharge, and although none has returned to his or her previous occupation, each is now looked after by family in a home-care setting.

DISCUSSION

The question of appropriate indications for surgical removal of ICHs is being intensively debated in the literature at present[4,5,9] and will not be addressed further here. Various surgical approaches have been described to evacuate large, hypertension-based ICHs, including craniotomy and transcortical,[10,13] transsylvian,[6] and transcallosal[7] approaches. In addition, stereotactic aspiration with or without the use of fibrinolytic agents[8,11,17] has also been described. Finally, many surgeons have used endoscopic instrumentation to evacuate large ICHs.[1,2,12,16] The constraints of managing a very sick patient who often has multisystemic medical problems and hypertension together with the need for rapid, minimally invasive, and effective brain decompression tend to favor endoscopic techniques over open craniotomy (which takes more time and is not minimally invasive) and stereotactic approaches (which might take a few days to achieve effective thrombolysis and decompression[11]). Nonetheless, the endoscopic instrumentation and techniques described in the literature presently suffer from either inadequate instrumentation[16] or the need for expensive equipment.[1,2] We have found that working through long outer sheaths with preformed channels is too constraining, time consuming, and unnecessary.

Here, we have described a simple modification of the 4-mm rigid endoscope, which can be assembled by any neurosurgeon within a few minutes. Most multispeciality hospitals will have access to similar telescopes used by otorhinolaryngologists or orthopedic surgeons. By dispensing with the outer working channel of the instrument, the neurosurgeon enters the more familiar field of microneurosurgery, except that an endoscope is used for illumination rather than a microscope. The additional functionality of the endoscope (visually aligned electrocautery electrode and irrigation) increases the comfort level of the neurosurgeon. Most important, the possibility of using regular suction to evacuate the clot, rather than expensive morcellizing equipment described previously,[2] makes this procedure faster and easier for most neurosurgeons.

Another major advantage of the technique described here is the possibility of introducing bipolar forceps, cotton patties, and Surgicel into the hematoma cavity without compromising minimal invasiveness. Small capillary ooze has been recognized as a problem at the end of hematoma evacuation,[10] and the present technique solves that problem expeditiously.

Hand–eye coordination presented a particular challenge in a few initial cases, thus requiring the suction tip to be kept in endoscopic view at all times. Nonetheless, this difficulty was easily overcome by practicing the maneuver in the lab by using a melon as a model. It was also important to learn to handle instruments through the cortical tunnel without retracting the brain too much, while fixing the gaze at the endoscopic images on the monitor. Given that the entire procedure is performed freehand, with no tactile feedback from the endoscope holder, these skills of instrument handling are particularly important in this setting.

Another criticism of the technique described here might be that it does not use stereotactic or navigation techniques for hematoma localization. Considering that only patients with large clots underwent surgery, we find such localizing techniques unnecessary. Careful preoperative evaluation of the radiological studies allows appropriate craniotomy placement and trajectory determination, without spending too much time.

CONCLUSIONS

We have described a new, minimally invasive endoscope-assisted technique for the evacuation of large, hypertension-based ICHs. Furthermore, we have demonstrated that safe and rapid evacuation of large clots can be accomplished, although the long-term outcome in most patients remains poor. The surgical technique described in this paper is faster, cheaper, and better than those described in the earlier literature. Further research to determine the appropriate indications for such surgical procedures is required.

Acknowledgments

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Disclosure

The authors have no financial interest in the instruments under discussion. The instrumentation used in this study was provided by and belongs to the Vidyasagar Institute of Mental Health and Neurosciences, New Delhi, India.

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