Perspective

Endoscopic treatment of hypertensive intracerebral hemorrhage: A technical review

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Abstract

Hypertensive intracerebral hemorrhage (ICH) is still a highlighting global issue. Endoscopic evacuation as a minimally invasive treatment became an alternative other than conventional craniotomy and catheter drainage for ICH. However, there is no unified indication or standardized procedure on endoscopic treatment of ICH. Here we explored the literature and gathered information from different studies, to review the background, technical points, and existing problems of endoscopic treatment for ICH.

Keywords: Endoscopic treatment; Hypertension; Intracerebral hemorrhage (ICH); Hematoma evacuation

Introduction

Intracerebral hemorrhage, formerly referred to as “hypertensive hemorrhage”, is the second most common (31.5%), but the most deadly (51.7%) form of stroke throughout the world. Recent findings have estimated that the absolute number of people with incident hemorrhagic stroke increased significantly by 47%, yet reduction in the mortality, in disability-adjusted life-years (DALYs), and in mortality-to-incidence ratios rates, which possibly related with medical improvements and global population expansion. Although the rates statistically reduced, the median 30-day mortality following ICH is still approximately 40%, and the 1-year mortality is up to 64%. Moreover, among the population who suffered from ICH, only 20% of the patients can survive independently at 6 months, which indicates the importance. However, the cost of survivors for hospitalization together with the first year post-discharge therapy can reach more than 44,000 dollars, which is a great economic burden, especially for low-income countries.

The most important risk factor for ICH is hypertension. A meta-analysis showed that blood
pressure of >160/90 mmHg increased the risk of intracerebral hemorrhage more than ninefold. Smoking and drinking are also compelling evidence for intracerebral hemorrhage. Medication such as warfarin and aspirin can also contribute to ICH, although their benefits far outweigh the potential risks. Moreover, the incidence of ICH was 15% lower in women than men, though not statistically significant. Age and hypertension are main etiologic factors. Hypertensive hemorraghes are the most common cause of ICH in patients aged 45–70 years and are more likely to be located in the deep brain structures such as the putamen (60–65% of cases), thalamus (15–25%) and pons/cerebellum (10%). In patients <45 years old, the most important etiology is underlying vascular lesions such as arteriovenous malformations, cavernomas or aneurysms.

General management of ICH contains medical and surgical treatment. Population-based studies show that most patients present with small ICHs that are readily survivable with good medical care. Patients with cerebellar hemorrhage who are deteriorating neurologically or who have brainstem compression and/or hydrocephalus from ventricular obstruction should undergo surgical removal of the hemorrhage as soon as possible (Class I; Level of Evidence B). However, the role of surgery for most patients with spontaneous ICH remains controversial. When there is uncertainty of preferred treatment present, International Surgical Trial in Intracerebral Hemorrhage (STICH) and minimally invasive surgery (MIS) treatment for the patients with spontaneous supratentorial intracerebral hemorrhage (MISTICH) can be a reference. STICH showed early surgery in patients with spontaneous supratentorial intracerebral hematomas has a 2.3% absolute benefit (95% CI: 3.2–7.7) and 10% (95% CI: 13–33) relative benefit over initial conservative treatment, but no overall benefit. In the following STICH II states that early surgery has a small but clinically relevant survival advantage for patient with spontaneous superficial intracerebral hemorrhage without intraventricular hemorrhage.

Surgical intervention for ICH mainly consists of three general methods, conventional craniotomy, endoscopic treatment, and catheter drainage. The gist in surgical intervention for ICH is to remove clot, to relief mass effect, and to reduce cytotoxic and peri-hematoma edema. With the development of medical instrument and the deeply rooted “Minimal invasive” concept, endoscopic hemorrhage evacuation for treating hypertensive ICH is becoming more and more popular.

The first controlled randomized study about Endoscopic surgery versus medical treatment for spontaneous intracerebral hematoma was reported by Ludwig M. Auer, et al. in 1989. The study demonstrates a significantly lower mortality rate (30%) than the medically treated group (70%, P < 0.05) for subcortical hematomas. However the outcome of surgical patients with putaminal or thalamic hemorrhage was no better, but the trend to become better quality of survival and chance of survival in the operated group. Later studies showed a same to higher evacuation rate from 79.2% to 99% with significant compared with craniotomy. Complications were more frequent in the craniotomy group. There was no difference in the occurrence of other complications, including revision surgery digestive tract ulcer and epilepsy. Proportion of patients with good prognosis (ADL I–III) was larger in the keyhole group (P < 0.05). The mean change in Glasgow Coma Scale (GCS) score was +4.8 for the endoscopy group and −0.1 for the craniotomy group (P < 0.001).

The general procedure of endoscopic clot evacuation including creation of a linear skin incision (3–4 cm) and a 1−2.5 cm bur hole or a small craniotomy is then created with dura opened in “Z” shape. A stylet or introducer was inserted into through pre-operative designed approach to favorable depth. Along the stylet or introducer, gently cannulate with a sheath through normal brain tissue to the hemorrhage with calculated depth. Under endoscopic direct visualization, mainly using suction to remove the hematoma. After satisfied intra-operative hemostasis and irrigation, placing coagulate and gradually retracting the sheath from deep to surface to clear up the hematoma cavity. With or without drainage, close the patient up in standard process.

Pre-operatively, neuroimaging is mandatory. Computed tomography (CT) and magnetic resonance imaging (MRI) are both reasonable for initial evaluation. Moreover, neuroimaging can be later used for surgical planning and navigation. Blood pressure should be maintained under 140 mmHg of systolic blood pressure (SBP), avoiding using nitroglycerin which may increase ICP. Decompression craniotomy should be performed for consistent high ICP post-operatively. Patients with catheter after surgery can accept further treatment through the drainage, if hematoma residual was found by postoperative CT. A study showed minimally-invasive surgery plus recombinant tissue plasminogen activator (rtPA) for intracerebral hemorrhage evacuation has tentative grater clot resolution than traditional medical management.
**Crucial technique points and options for endoscopic evacuation of ICH**

**Instruments for endoscopic evacuation of ICH**

Endoscopes that can serve the duty for illumination and close visualization are encouraged to use, either rigid or flexible endoscope, with or without irrigation system. 0° is more popular than 30° endoscope for clot removal. For the manipulation with endoscope and suction, an approaching passage is required. Earlier, evacuation was carried out through endoscopic troca or customized syringe. In the recent 20 years, more available sheaths were designed to reduce damage to normal brain tissue along the cannulation, and provide with further advantages, such as stainless steel sheath, NeuroPort, ViewSite, and other expandable cannula system (Fig. 1). The sheath can be secured with holders or used in a flexible style. Moreover, other equipment and customized instruments are gradually introduced to facilitate this surgery.

**Approaches to the hematoma**

Approaches are carefully designed according to the location of hematoma. For hematoma in basal ganglia, 2–3 cm anterior to coronal suture and 3–4 cm lateral to the midline is preferred as the entry point. For thalamic hematoma, a parietal entry point is preferred. For subcostal hematoma, a shortest approach is preferred. The endoscope is commonly through the approach and inserted to two-thirds of the hemorrhage along the axis. Other approaches, such as frontal bur hole and Keyhole approach are also in consideration to surgeons preference. Recently, a dual-channel approach was reported for a better visualization with endoscope, however, would cause substantial damage compared to the others.

**Methods for evacuation and hemostasis**

In order to avoid damaging the brain parenchyma with excessive manipulation of the sheath, hematoma was removed from the most distal part and as the sheath is gradually withdrawn the residual hematoma will be pushed into the tip of the sheath as the brain expands. The hematoma is evacuated by manipulating the suction through the working space within the sheath. About 70% of ICHs could be evacuated without an obvious or active bleeder being identified intra-operatively. Another theoretically method to remove the hematoma is described by Nagasaka et al. as the inflation—deflation. A clot that is adhesive to the hemotoma cavity should not be sucted with force. Instead, rolling the clot gently with snowball motion to free it with surrounding malacotic brain tissue, then remove it with forceps.

Most bleeding from these perforators stopped after gentle compression with cotton and irrigation for 2 min, which is described as wait-and-see saline irrigation. When bleeder is identified with an endoscope, coagulation would be preferred. With the endoscope held by an assistant or robotic arm, the bleeder can be ideally coagulated with bimanual manipulation with bipolar and suction. Another way is the surgeon holding the endoscope in one hand and the other hand gently retracting the bleeder with suction, letting the assistant to coagulate the bleeder by touching the

![Fig. 1. Schematic diagram showing the use of a new endoscopic port system which we developed (VDY20115, Jingcheng Medical Instruments, Shanghai, China). A, After dura opening, an introducer was inserted into hematoma with preoperative design; B, Remove the pith inside the introducer and draw blood through the introducer with a syringe to make sure it is inside the hematoma (Some systems may skip this step); C, Insert the working port along the introducer and further dilate the trajectory; D, Withdraw the introducer; E, Place the working port in ideal position; F, Remove the upper wing (only in this system) and secure the working port with standard retraction system (such as Leyla retractor) or with free hand.](image-url)
suction with monopolar. However, caution should be taken that the monopolar would not shock the endoscope through the contact with the suction. When specific devices are available, such as Apollo vibration/suction device, it is also a good option. Moreover, some hemostatic agent can be also applied such as Floseal (Baxter) for intraoperative hemostasis.

**Localization and navigation**

As a fact of limited working space, an accurate localization and navigation will promote the evacuation rate. Across the literature, neuronavigation is the most commonly used method. The insertion of the sheath will be navigated to specific target inside the hematoma. Besides the standard navigation system, there are more available options such as using iPhone or iPod to identify the location on scalp of the patient with pre-operative CT. Image-guided surgery mainly based on CT to target hypertensive hemorrhage were described by neurosurgeons worldwide instead of neuronavigation.

The biggest disadvantage of neuronavigation or image-guided localization is intraoperative shift. In compensation for intraoperative shifting, ultrasound is introduced as a real-time navigation for the insertion of the sheath, and it also provides real-time viewing of the hematoma in case of residual. However, the application of ultrasound may require extra space for ultrasound probe, which may cause additional damage to the patient.

**Tips for patients on anti-coagulation medication**

The incidence of anticoagulant-related ICH is increasing, as the use of anticoagulants rises. Patients who receive warfarin therapy should use Vitamin K or fresh frozen plasma to reduce the dose of warfarin within 24 h of onset. Reversal of unfractionated heparin can be accomplished with intravenous protamine sulfate.

**Indication and timing for endoscopic treatment**

There is no commonly agreement on indication and timing for surgical treatment for ICH, and so is with endoscopic treatment. However, study shows that ultra-early surgery (within 4 h from onset) is associated with an increased risk of rebleeding in surgical treatment of ICH. Another study analyzed different surgical treatment of ICH, suggesting when the endoscopic operation was performed within 6–12 h, the mortality rate was lower than conventional craniotomy and drill drainage ($P < 0.05$). In one meta-analysis of randomized controlled trials indicated that patients with supratentorial intracerebral hemorrhage might benefit more from MIS than other treatment options. Patients with GCS score of $\geq 9$, hematoma volume between 25 and 40 ml, and within 72 h after onset of symptoms, would benefit more from MIS. The 2014 guidelines from the European Stroke Organization indicated that surgery might be of value in patients with a GCS of 9–12. STICH II trial suggested a potential benefit of early surgical evacuation (within 60 h) in patients with supratentorial hemorrhages between 10 and 100 ml.

**Discussion**

Theoretically, endoscopic treatment has many techniques underlying. One major advantage of using endoscope is reducing manipulation of viable brain tissue. Instead of conventional retraction with blades, the working channel is provided mostly by a cylinder sheath, which goes directly into the hematoma and serves as a full range retractor with sufficient space for endoscopic evacuation. In order to gain maximal evacuation with the stingy exposure, the port could be gently tilted within the hematoma without excessive retraction. Some systems are designed with transparent scaled sheath and stepwise expansion, extending both visual and special field. The manipulation of the sheath and the flexibility of the visualization from endoscope could compensate for microscopic visual limitations in conventional craniotomy. Moreover, the sheath stands against the surrounding, providing steady hemostasis.

Another advantage of the endoscopic evacuation is the small incision and the delicate craniotomy (sometimes a bur hole), which reduces unnecessary blood loss in large craniotomy.

Catheter drainage, as well as a minimal invasive method for ICH evacuation, has the least blood loss, however, without direct visualization. A major disadvantage of drainage is the difficulty for clots going through the catheter.

A possible solution in this condition is to inject urokinase and flush with sterile saline through the catheter and keep it inside the hematoma cavity for 60 min before reopening the drainage. As a result, the timing and drainage procedure for using catheter drainage would be tricky and restricted compared to other surgical treatment.

Clinically, more and more study illustrated that endoscopic treatment of ICH is superior to conventional craniotomy in modality, motility. The surgery duration...
and recover time are shorter than conventional craniotomy, yet with less complication rate. Although the difference in endoscopic group has an overall absolute better outcome, it is still non-statistical significant.

Endoscopic treatment is a potential advanced alternative for ICH, but not yet recommended by guidelines, there are some possible reasons.

Firstly, endoscope, compared to catheters, is still relatively expansive, which may not be available in every hospital, which also requires handle with attention and investment with further annually maintenance.

Secondly, endoscopic techniques are not so commonly acquired compared to microsurgical techniques. Neurosurgeons are more familiar with microscope and microscopic bimanual manipulation in 3-dimensional visions. The 2-dimensional vision and the differences in handling with instruments may discourage some surgeons.

Thirdly, but most importantly, there is no convincing evidence showing a significant advantage of endoscopic treatment over other options. All the data showed a promising trend, but still not powerful enough. Now, more clinical trails are carrying on to figure out the relationships among different methods, especially the comparison between endoscopic and conventional craniotomy. Maybe later with these study, finally comes the commonly agreement on the indication or reliable recommendation.

Studies and experiences published in the past three decades are mostly in favor of evacuating the clot endoscopically while gaining a promising outcome. The clinical trials through years are changing from testing the feasibility of endoscopic evacuation of ICH to improving outcome by seeking better way of navigation, or decreasing the potential damage.

Conclusion

Many studies have pointed out endoscopic treatment of ICH has better outcomes with less invasive approaches, though no statistical difference compared with conservative medical treatment. However, the difference does encourage further study, because there are still patients who can benefit from this method. Later with better definition in patient selection and proper perisurgical treatment, endoscopic treatment might profit more patient with hypertensive ICH.

Conflicts of interest

Yi-ning Zhao has received national scholarship from Chinese Scholarship Conceal for doctoral degree study in Germany. There is no conflict of interest or relevant affiliation with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

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