Dual-Channel Minimally Invasive Endoscopic Port for Evacuation of Deep-Seated Spontaneous Intracerebral Hemorrhage with Obstructive Hydrocephalus

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■ BACKGROUND: **In minimally invasive endoscopic port surgery, the medium is air, and the image is clearer than in fluid. The most commonly used port is a single-channel port, which accommodates the rod lens of the endoscope and 2 microsurgical instruments. This setup decreases the freedom of movement of the 3 instruments, making the bimanual procedure difficult. We describe a novel "dual-channel" endoscopic port to facilitate a bimanual refinement procedure for removing deep-seated spontaneous intracerebral hematomas, and we demonstrate the feasibility of this method.**

■ METHODS: **The small channel accommodates a 0° endoscope lens, and the large channel accommodates 2 microsurgical instruments. This method was used in 8 patients with deep-seated spontaneous intracerebral hematomas with obstructive hydrocephalus. It was necessary to evacuate the deep-seated hematomas in these patients as soon as possible to recover the circulation of cerebrospinal fluid.**

■ RESULTS: **Dual-channel port surgery was performed in 8 patients with an average age of 55 years (range, 44–79 years). The time from ictus to surgery ranged from 4 hours to 12 days. The duration of drainage tube placement was 2–5 days. The hematomas in all patients, in the third ventricle or thalamus, were evacuated thoroughly. In each patient, improvements in Glasgow Coma Scale scores were observed from admission to discharge.**

■ CONCLUSIONS: **The dual-channel endoscopic port facilitated bimanual refinement microsurgery during the evacuation of deep-seated intracerebral hematomas, and it prevented the disturbance of the 3 instruments without restraining the scope of the operation during the microsurgical procedure.**

INTRODUCTION

Parallel to the popularized use of self-retaining brain blades, the concept of a port retractor system (i.e., tubular or sheath) was introduced in the late 1980s.[1] Some studies have demonstrated that the port redistributes pressure more equally in the surrounding tissue, and it causes less direct cutting and/or tearing trauma to the underlying brain tissue.[2,3] The diameter of the port used in microscopic surgery ranges from 20 to 30 mm. In endoscopic neurosurgery, the diameter of the port is 11.5–20 mm.

In minimally invasive endoscopic port surgery, the medium is air, and the image of the hematoma is clearer than in the fluid medium. More endoscopic port surgeries have been performed not only for hematoma evacuation but also for tumor resection.[4-8] The port accommodates the rod lens of the endoscope and 2 microsurgical instruments. This minimally invasive port surgery incorporates the priorities of endoscopic visualization and microsurgical bimanual refinement procedures.

The most commonly used port is a single-channel port. We employed a single-channel port to evacuate hematomas in 13 patients.[9] The diameter of the port was 14.5 mm. However, this single-channel port setup decreased the freedom of movement of the 3 instruments, making the "bimanual procedure" difficult.

Key words
- Dual channel
- Endoscopy
- Intracerebral hemorrhage
- Port retractor

Abbreviations and Acronyms
EVD: External ventricular drainage
GCS: Glasgow Coma Scale
ICH: Intracerebral hemorrhage

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The interference of the 3 instruments in a single-channel port was also noted by Bergsneider,[10] Masuda et al.,[11] and Hong et al.[12] Bergsneider[10] and Masuda et al.[11] employed different dual-port techniques to ameliorate the difficulties encountered when placing 3 instruments in 1 port during surgery. Hong et al.[12] concluded that when the port was used as a surgical corridor, the presence of an endoscope inside the port in endoscopic port surgery decreases the freedom of movement of other instruments, limits fine dissection, and prolongs surgery compared with microscope-assisted port surgery.

We devised a "dual-channel" port, in which the small channel accommodates the rod lens of the endoscope, and the large channel accommodates the 2 microsurgical instruments. The length of the small channel is only 3 cm, which precludes disturbance among the 3 instruments without restraining the scope of the operation during the microsurgical procedure. We have acquired national utility patents in China for this port (2013208486451).

The dual-channel port was used to evacuate hematomas in 8 patients who had medial thalamic hematomas or severe intraventricular hemorrhage; all 8 patients had acute obstructive hydrocephalus. These hematomas were located in the third ventricle or thalamus. Bimanual refinement procedures are very important to evacuate these hematomas. We describe the application of the dual-channel port to evacuate the hematomas and demonstrate that the dual-channel port can prevent the interference of these 3 instruments and allow the bimanual procedure to proceed more fluently during the operation.

MATERIALS AND METHODS

Description and Use of Instrument

The dual-channel port consists of a small sheath, a large sheath, and an obturator (**Figure 1**). The 2 sheaths are thin-walled transparent cylinders with a sheath thickness of 0.35 mm. The large sheath is 14.5 mm in diameter and 90 mm in length, and the small sheath is 6.5 mm in diameter and 30 mm in length. Indexing marks on the outer part of the large sheath facilitate the measurement of depth. The obturator fits inside the large sheath. The distal end is wedge-shaped, separating the walls of the linear white matter incision as the obturator is advanced.

Figure 1. Photographs depicting the use of the "dual-channel" endoscopic port. (**A**) The port consists of a small sheath, a large sheath, and an obturator. (**B**) The obturator fits inside the large sheath. (**C**) The obturator is removed, leaving the large sheath alone. Then the small sheath is attached to the large sheath. (**D**) Lateral view of the ensemble of the dual-channel endoscopic port.

A 15-mm burr hole is created. The dura mater is opened in a cruciate fashion. Then a corticectomy is performed. Cannulation with the obturator is typically targeted into the frontal horn of the lateral ventricle. After the conduit is advanced down toward the level of the ependymal surface, the obturator is removed, leaving the large sheath alone. The small sheath is subsequently attached to the large sheath. The small transparent sheath accommodates a 0° endoscope lens with a washing sheath (6 mm in diameter and 17 cm in length; Storz, Bausch and Lomb, Rochester, New York, USA). The large transparent sheath accommodates a bayonet-shaped, slim, bipolar electrocauterizer, suction instruments, or extendable microsurgical instruments (Figure 2).

Video

Video available at WORLDNEUROSURGERY.org

Surgical Procedure

The surgical procedure was performed under general anesthesia with the patient in the supine position. A 3-cm incision was made at Kocher point, anterior to the coronal suture and 2.5 cm lateral to the midline of the head. Then a 15-mm burr hole was drilled. The dura mater was coagulated and incised in a cruciate fashion. A 13-mm linear cortical incision was made. A transcortical transventricular puncture was made with a common brain puncture needle. When the ventricle was reached, the brain puncture needle was removed.

The port was cannulated according to the trajectory of the brain puncture needle. The small sheath was attached at the 12 o'clock position relative to the large sheath for orientation during the operation. The bloody cerebrospinal fluid was aspirated, creating an air environment for surgery to proceed. Bimanual refinement microsurgery was employed to evacuate the hematoma. The hematoma in the lateral ventricle was first evacuated. Then the hematoma in the third ventricle was evacuated through a transforaminal approach. Finally, the hematoma in the thalamus was evacuated (Figure 3, Video 1). A drainage tube was left in the third ventricle through the foramen of Monro or the cavity of the thalamus. If there was hematoma remaining in the ventricle causing obstructive hydrocephalus, urokinase (10,000 U) was injected to dissolve the hematoma. If there were no signs of obstructive hydrocephalus, the tube was removed. Bleeding arteries were coagulated using a conventional slim bipolar cauterizer, and bleeding veins were stopped via tamponade using hemostatic agents, such as Surgicel (Ethicon, Inc., Somerville, New Jersey, USA).

RESULTS

Initial neurologic status was assessed using the Glasgow Coma Scale (GCS) and the modified Rankin Scale, based on the admission examination. Postoperative neurologic status was assessed by GCS score at the time of discharge and by modified Rankin Scale score at the 1-month follow-up evaluation. Hematoma volumes were calculated using the following formula: (length × width × height)/2. Intraventricular hemorrhage scores were calculated using the Graeb scale.[13]

Dual-channel port surgery was performed in 8 patients with an average age of 55 years (range, 44–79 years). The time from ictus to surgery ranged from 4 hours to 12 days. The duration of drainage tube placement was 2–5 days. Demographic and clinical data of the patients are listed in Table 1. Computed tomography scans of patients are shown in Figures 4 and 5. No patients experienced hypothalamic storm, hyperthermia, or diabetes insipidus.

Improvements in GCS scores were observed in each patient from admission to discharge. The median admission GCS score

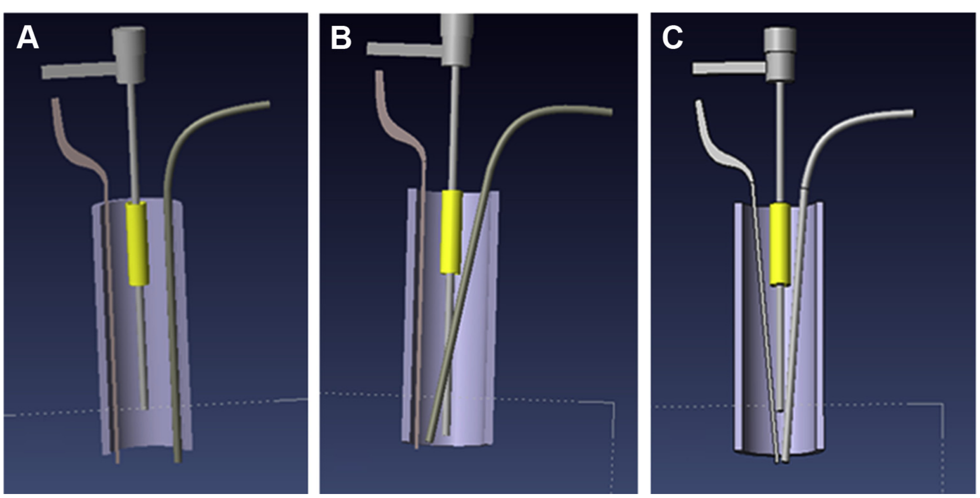

Figure 2. Schematic diagram shows how the dual-channel endoscopic port works. The yellow sheath represents the small sheath that accommodates the endoscopic lens, which is 30 mm in length. The other 2 instruments in the large sheath represent the bipolar electrocautery and suction. The small sheath restricts the activity of the endoscopic lens but does not preclude the extension of the 2 microsurgical instruments. (**A**) The 2 instruments work at the border of the sheath alone. (**B**) The 2 instruments cooperate at the border of the sheath. (**C**) The 2 instruments work at the center of the sheath.

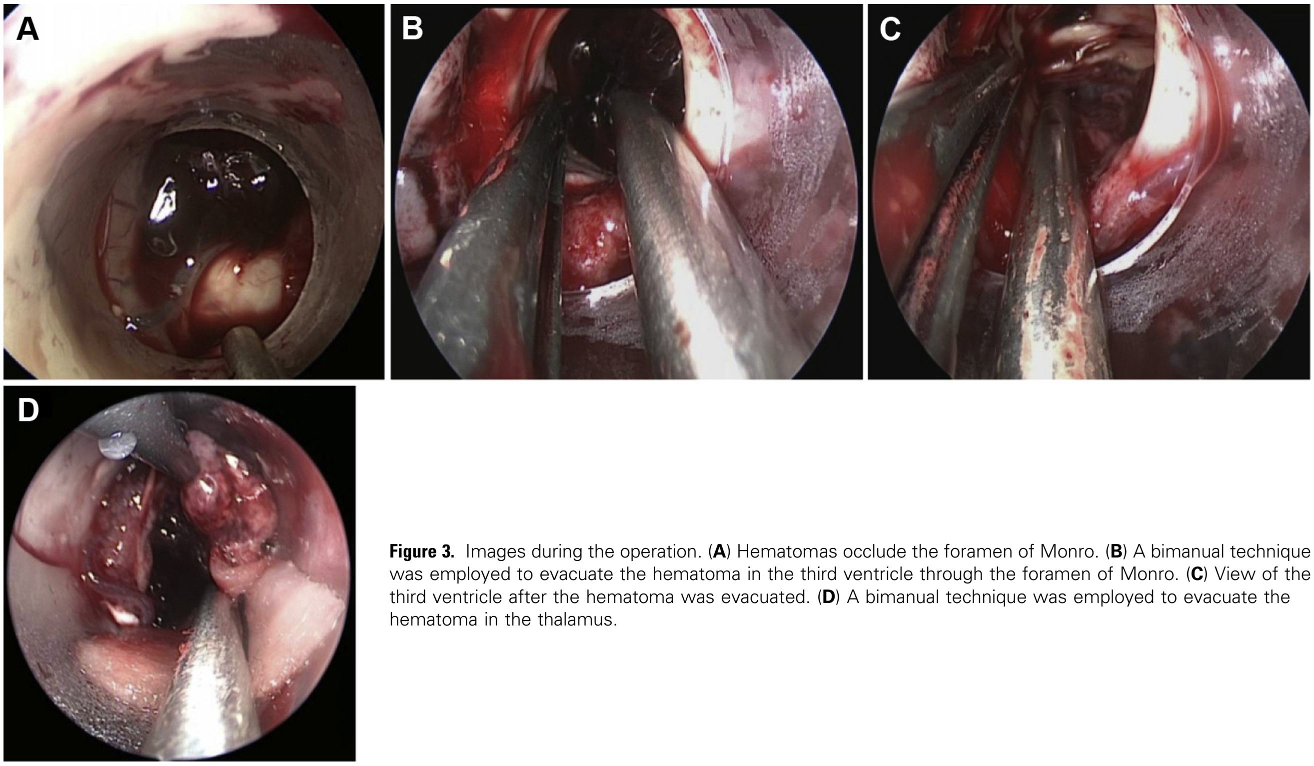

Figure 3. Images during the operation. (**A**) Hematomas occlude the foramen of Monro. (**B**) A bimanual technique was employed to evacuate the hematoma in the third ventricle through the foramen of Monro. (**C**) View of the third ventricle after the hematoma was evacuated. (**D**) A bimanual technique was employed to evacuate the hematoma in the thalamus.

was 4.5 (range, 3—10), and the median discharge GCS score was 7 (range, 6—13). Improvements were also observed in the modified Rankin Scale scores of case 1 and case 2 from admission to the 1-month follow-up evaluation. Cases 6 and 8 had hydrocephalus during follow-up, and their health care agents refused further surgery.

Case Presentation: Case 7

A 55-year-old man presented with a left medial thalamus hematoma rupture into the ventricle and obstructive hydrocephalus. GCS score on admission was 3. The patient underwent an emergency external ventricular drainage (EVD) procedure, and urokinase (10,000 U) was instilled twice a day. The hematoma in the thalamus did not dissolve by the 12th day after EVD. The drainage tube was not removed because of hydrocephalus. On the 13th day after EVD, the patient underwent a dual-channel endoscopic operation. During the operation, the yellowish hematoma of the thalamus ruptured into the lateral ventricle. The hematoma was rigid and stuck to the surrounding brain tissue, which led to diffuse bleeding during the evacuation. The dual-channel port

Table 1. Patient Information

Case	Age (years)	Admission GCS and mRS Scores	Hematoma Location	ICH Volume/IVH Score	Ictus to Operation	Duration of Drainage Tube (days)	Discharge GCS Score	1-Month mRS Score
1	44	6/5	IVH	0/12	10 hours	3	13	3
2	56	10/5	Thalamus	13 mL/7	18 hours	4	13	3
3	51	4/5	Thalamus	15 mL/10	7 hours	2	9	5
4	79	6/5	Caudate	10 mL/11	9 hours	4	8	5
5	45	3/5	Thalamus	6 mL/9	8 days	5	6	5
6	56	4/5	Thalamus	27 mL/10	4 hours	3	7	5
7	55	3/5	Thalamus	25 mL/3	12 days	3	6	5
8	56	7/5	IVH	0/11	21 hours	4	11	5

GCS, Glasgow Coma Scale; mRS, modified Rankin Scale; ICH, intracerebral hematoma; IVH, intraventricular hemorrhage.

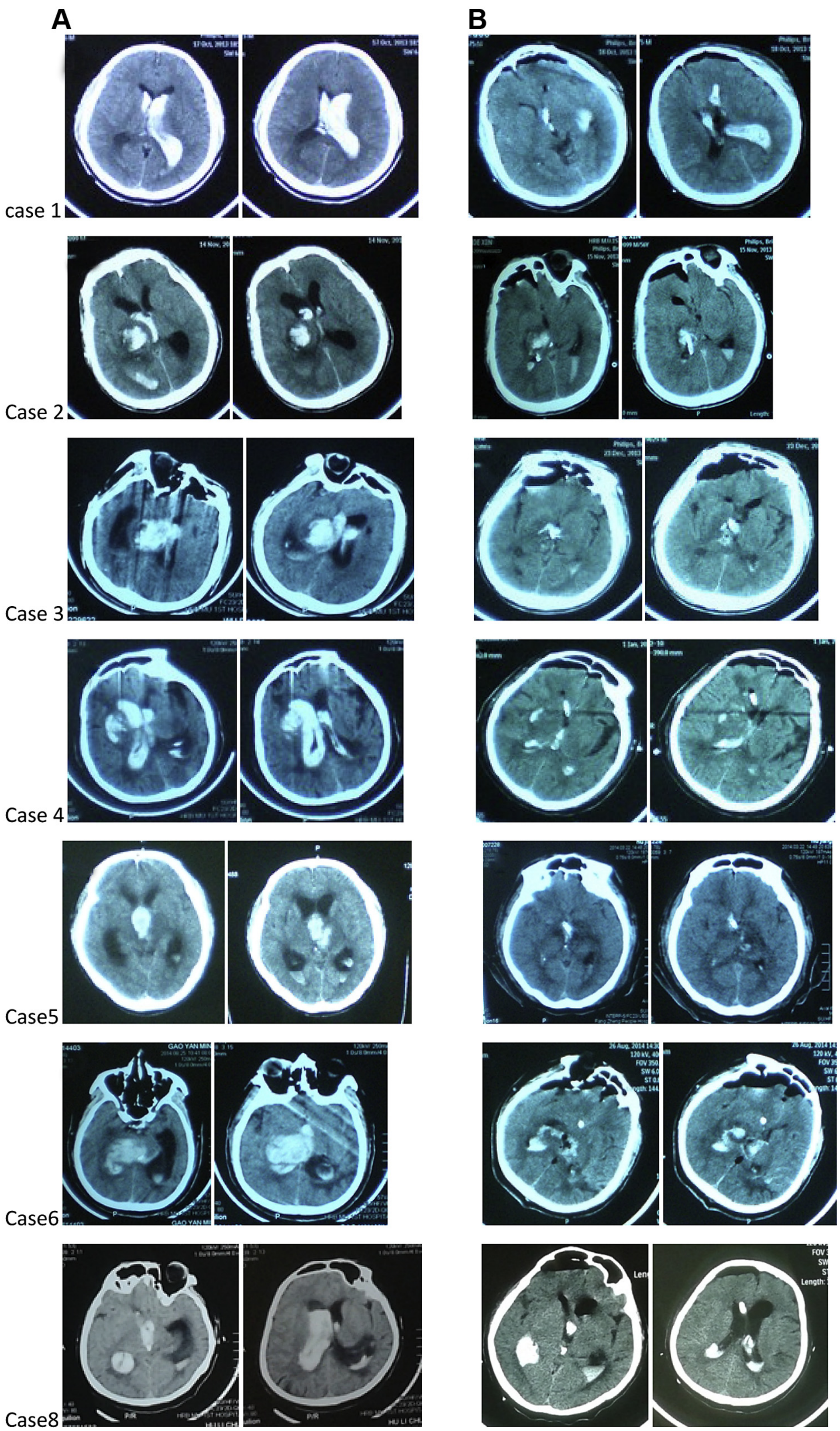

Figure 4. Preoperative (**A**) and postoperative (**B**) computed tomography scans of each patient in this study except for case 7.

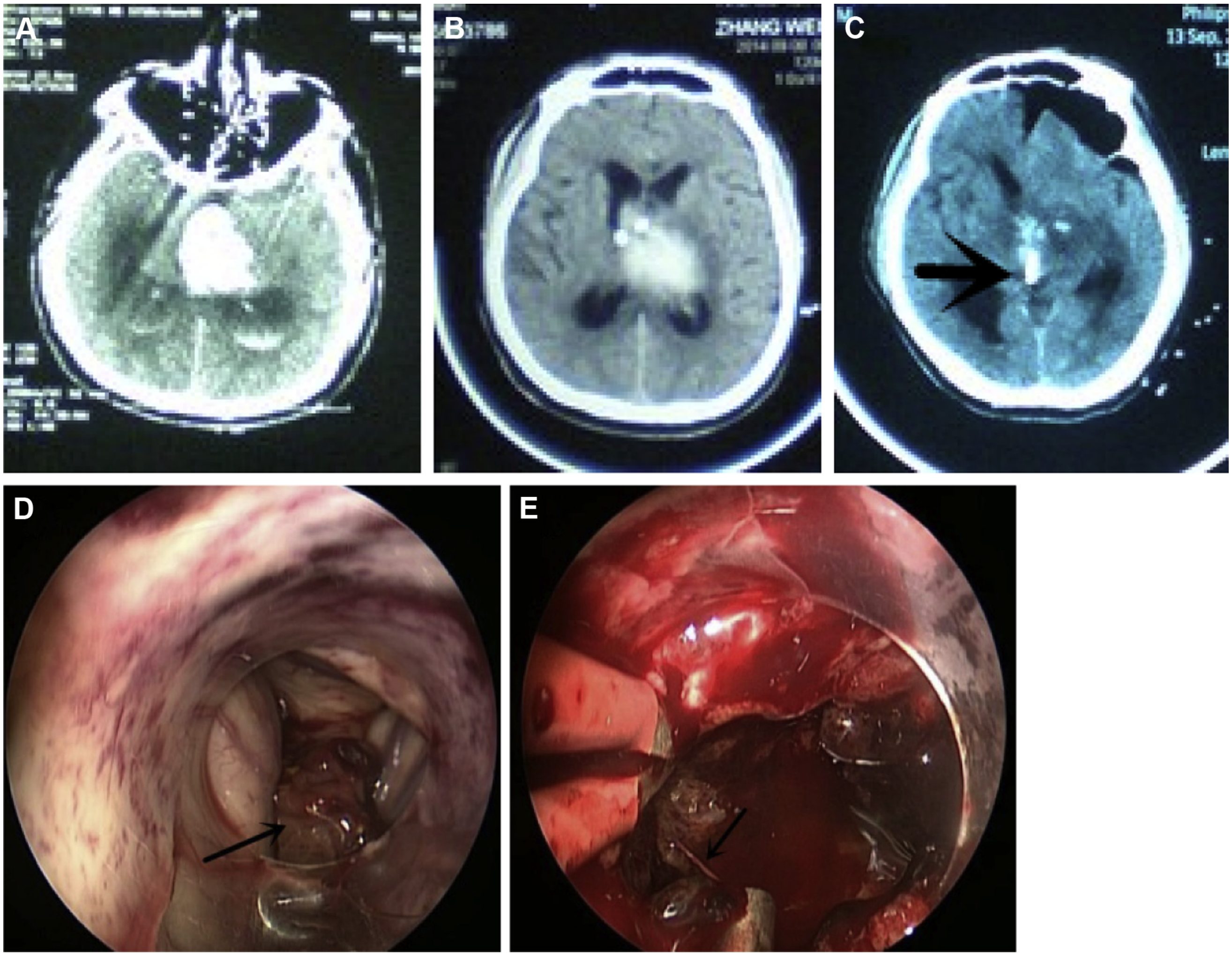

Figure 5. Case 7. (**A**) Computed tomography (CT) scan at admission revealed a left medial thalamus hematoma rupture into the ventricle and obstructive hydrocephalus (before external ventricular drainage). (**B**) CT scan of the patient on day 12 after external ventricular drainage and before endoscopic operation. (**C**) CT scan on the first day after endoscopic operation. The hematoma in the thalamus was evacuated. The *arrow* indicates the drainage tube in the thalamus. (**D**) View of the operation, in which the yellowish hematoma of the thalamus ruptured into the lateral ventricle. The *arrow* shows the hematoma. (**E**) A bimanual technique was employed to achieve hemostasis at the time of evacuating the hematoma in the thalamus. The *arrow* shows the bleeding vessels.

made hemostasis more effective by a bimanual procedure. The solid hematoma in the thalamus was evacuated. The hydrocephalus was eliminated, and the tube for EVD was successfully weaned on day 3 after the endoscopic operation. There was no complication related to the injury to the thalamus (Figure 5).

DISCUSSION

Endoscopic port surgery, in which a transparent cylinder port is employed, is widely accepted in clinics. The port pushes away the subcortical fasciculi, and it has been demonstrated to cause less injury to the peripheral tissue of the hematoma compared with the common brain retractor.[2,3,7,12,14]

By virtue of the endoscope's proximity to anatomic structures, endoscopic operations require a less narrow port than microscopic operations. The diameter of the endoscopic port is 11.5—20 mm. The bimanual refinement of the microsurgical procedure is very important for the evacuation of hematomas and for hemostasis during the operation, especially for hematomas in important locations, such as the third ventricle and thalamus, which occurred in case 7 (Figures 4 and 5).

At the present time, single-channel endoscopic ports are used when bimanual procedures are employed, in which 2 microscopic instruments and 1 endoscopic camera are inserted into the narrow port. These 3 long rod apparatuses would be in a parallel fashion in case of obstruction. Single-channel ports hamper bimanual procedures.[10-12] Some authors have opted to change from a single port to different types of dual ports to facilitate bimanual operations during endoscopic surgeries.[10,11]

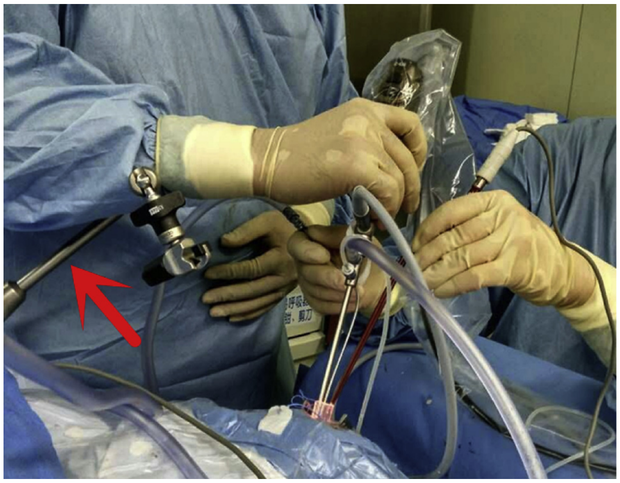

Figure 6. Operative procedure. The assistant holds the rod of the lens. The hand bracket (*arrow*) for the assistant makes it easier to coordinate with the operator.

These dual-port techniques might cause more serious injury to brain tissues, and they are not widely used.

Nagatani et al.[15] employed a high-definition exoscope (VITOM; KARL STORZ GmbH & Co., Tüttlingen, Germany) to spare the space of the rod lens of the endoscope. The VITOM was a novel piece of equipment, and its large focal distance allowed it to be placed sufficiently far away from the surgical site. Compared with the exoscope, the virtue of the endoscope's proximity to anatomic structures had many advantages, such as ease of focus and multiple angle observation.

We modified the dual-channel port in line with "multiple access port" trocar of the single-port laparoscopic surgery.[16] The small channel accommodates a 0° endoscopic lens with a washing sheath, whereas the large channel accommodates 2 microsurgical instruments. The small sheath is 30 mm in length, restricting the activity of the endoscopic lens, but it does not preclude the extension of the 2 microsurgical instruments. The advantages of the dual-channel endoscopic port have been demonstrated in clinical practice. It is easier to evacuate hematomas in the third ventricle and thalamus through the dual-channel endoscopic port (**Figures 4** and **5**). There are some important structures around the foramen of Monro and thalamus, such as the thalamostriate vein, internal cerebral vein, and choroid vein. Injury to these important structures could cause hypothalamic storm, hyperthermia, or diabetes insipidus. The dual-channel endoscopic port made bimanual refinement feasible and fluent. No catastrophic complications occurred during the 8 procedures.

Application Notes

1. During the procedure, blood always blurred the lens. The washing sheath (6 mm in diameter and 17 cm in length; Storz, Bausch and Lomb) was more effective in keeping the lens clear. Thus, the washing sheath is recommended.
2. The position of the rod lens would always need to be changed. The holding arm of the endoscope did not satisfy this requirement. The rod of the lens was held by an assistant because the hand bracket made it easier for the assistant to hold the rod of the lens and coordinate with the operator. Thus, the hand bracket for the assistant is recommended (**Figure 6**).
3. The thickness of the sheath is 0.35 mm. The dual-channel port is very light, and its position can be easily maintained. The port seldom needs to be fixed. In addition, the position of the port needs to be changed, including the up and down directions, and it tilts in all directions. Fixation of the port is not recommended. When the port must be fixed during the operation, the assistant sometimes holds the lens in the right hand and fixes the port in the left hand.

CONCLUSIONS

The dual-channel endoscopic port facilitated bimanual refinement of microsurgery for the evacuation of deep-seated ICH, and it prevented disturbance of the 3 instruments without restraining the scope of the operation during the microsurgical procedure. We are confident that this dual-channel endoscopic port could be employed to treat other intracranial pathologic entities, such as many metastatic tumors and high-grade gliomas.[3,5-7,12]

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