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Case Report

Pure neuroendoscopic technique (PNET) in the treatment of intracerebral hemorrhage-an introduction of a new intracerebral hematoma surgery of convenient operation

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Abstract: Objective: To explore the appication value, technical key points and operation experience of pure neuroendoscopic technique (PNET) in the treatment of intracerebral hemorrhage. Methods: The clinical data of 25 cases with cerebral hemorrhage treated by PNET were analyzed retrospectively, including 20 cases with hypertensive cerebral hemorrhage, 3 with unknown causes 2 after operation. Hematoma location: 20 in the basal ganglion ragion, 2 in the frontal lobe, 1 in the parietal lobe, 1 in the occipital lobe. PNET and CT scan after operation were performed in all the patients. Results: The hematoma evacuation rate after PNET operation was 13 over 90%, 2 between 60% and 90% and 1 less than 60%. 1 case was converted to craniotomy for operation because of bleeding. Intracranial infection occurred in 1 case after operation and 2 cases using urokinase injection to treat residual hematoma. The length of scalp incision was 3 to 4 cm with a mean of 3.0 cm, the diameter of bone window was 1.1 to 1.2 cm, intraoperative blood loss was 40 to 100 ml with a mean of 50 ml, the operation time was 45 to 120 min with a mean of 65 min. The glasgow outcome scale (GOS) score 3 months after the operation revealed: recovered well in 3 patients, mild disability in 9, severe disability in 5 and no died cases. Conclusions: PNET treats cerebral hematoma just need one skull hole can complete the operation and practing processing proved excellent performance of convenient operation, small trauma, quick recovery and little complications. Technical points: choose a good hematoma puncture position, give full play to the transparent sheath and hematoma smashing suction apparatus, using water and air environment operation technology flexibly, and to remove the hematoma as much as possible in safety.

Keywords: Neuroendoscopes, cerebral hemorrhage, transparent conduit sheath, hematoma smashing suction apparatus, minimally invasive surgery

Introduction

The surgical operation is one of the most important means for the treatment of intracerebral hemorrhage. The conventional craniotomy evacuation of hematoma is characterized with a high hematoma clearance rate but with a huge operative trauma. Even though bur hole craniotomy is a simple and practical operation, it is characterized with large residual hematoma and could not lessen the secondary lesion the hematoma imposed on the brain tissues. Besides the overlong duration of hematoma drainage and thrombolytic therapy is likely to increase the possibility of the intracranial infection and the repeated bleeding [1-5]. In recent years neuroendoscope has been gradually explored to be applied into treatment of the cerebral parenchyma disease, such as the cerebral hemorrhage, and it has made great progress. But this technique has also been constrained by the factors such as the difficulty of endoscopic hemostasis and tough clot removal [6]. At present The neuroendoscope brain hematoma evacuation operation is an-endoscopic-assisted procedure (outside the endoscope). Pure neuroendoscopic technique (PNET) for intracerebral hemorrhage treatment

Figure 1. Neuroendoscopes and Transparent conduit sheath before assembly.

Figure 2. Neuroendoscopes and Transparent conduit sheath after assembly.

has not been reported before. 25 cerebral hemorrhage cases from July 2014 to December 2015 treated with PNET had a satisfied treatment effects. The report summary was showed below.

Material and methods

General information

The clinical data of 25 cases with cerebral hemorrhage (16 males and 9 females; age between 18-75 years old; mean age 53.4 years old) were enrolled in this study, including 20 cases with hypertensive cerebral hemorrhage, 3 with unknown causes, 2 after operation. The preoperative Glasgow coma scale (GCS) scores were between 5-12 points and the cerebral state index (CSI) was 72±9.4. The diagnosis was made with a CT scan before the operation. The cerebral hemorrhage volume was measured by the method of Tada formula with an average volume of 45±14.5 cm^3. Hematoma location: 20 in the basal ganglion region, 2 in the frontal lobe, 1 in the parietal lobe, 1 in the occipital lobe. Among these cases, 3 cases with unknown causes were those that had no vascular malformation in MRA/DSA examination, no history of hypertension, and whose blood pressure was normal after surgery; 2 cases of postoperative cerebral hemorrhage were those patients with hematoma which formed along with frontal lobe injuries caused by the frontal lobe retraction during the tumor operation.

The experiment was in accordance with the medical ethical standards and approved by the local ethical committee (The ethical code: NFEC-2015-034). The family's consent had been sought and the informed consent was signed. Besides, this study was also registered for the North America Clinical trial (the registration number: NCT02515903).

The inclusion and exclusion criteria

Inclusion criteria: ① adults under age 75, ② the hemorrhage was located in the brain parenchyma, and was not involved with the brain ventricular system ③ volume of cerebral hemorrhage was more than 30 mL and no brain hernia was formed ④ patients and their families agreed to the surgery and agreed to enter clinical study sequences and signed the surgical consent.

Exclusion criteria: ① serious systemic illness including serious dysfunction of heart, liver, lung and kidney; ② blood coagulation dysfunction; ③ those with brain aneurysm confirm edor suspectedor with a history of a cerebral vascular malformation hemorrhage.

Operation time: ① after admission a brain CT was immediately checked in an emergency departmentand 6 hours later, the review of the craniocerebral CT showed that hematoma volume had not increased which signified that patheints were in the stable state and could undergo the hemorrhage surgery ② operation time: 6 hours to 3 days after the initial CT examination.

Pure neuroendoscopic technique (PNET)

PNET equipment: PNET equipment applied in this study was comprised of HD imaging systems, cold light source, Zeppelin channel Endoscope, transparent conduit sheath, hematoma smashing suction apparatus (**Figure 3**) and the endoscopy-specific bipolar coagulation device, etc. The large working channel endoscope neuroendoscope: the model number was NEH 0/30-177-6.5, working length was

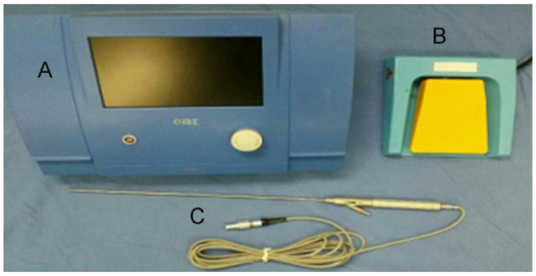

Figure 3. hematoma smashing suction apparatus (A. Mainframe; B. Suctionforec pedal control system; C. Head of the apparatus).

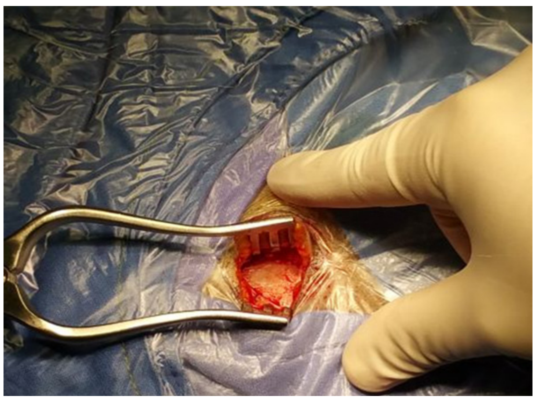

Figure 4. PENT surgical incision.

177 mm; Outside diameter 6.5 mm, visual angle was 0° or 30°; the diameter of working channel 3.7 mm, the diameters of the 2 catch/flushing channel 1.5 mm. Transparent sheath catheter was the national patented product through independent research and development (patent No. 1164847) it was seamlessly connected with the endoscopy and with an the outside diameters of 7 mm. Transparent sheath catheter was colorless and transparent, and came along with a scale, fastening device and transparent tip which could be drawn out along with the endoscope (**Figures 1**, **2**). The hematoma smashing suction apparatus with a diameter of 3 mm had an external power system and an inside crashing and aspirating apparatus, which was double controlled by gears and Pedals (**Figure 1**). Bipolar coagulation device was Zeppelin ZNE-242BIP, and it could stop bleeding through the working channel.

Operation method: All patients underwent the hematoma evacuation surgery under general an esthesia with endotracheal intubation. The puncture point was opted according to the cerebral CT scan, and was usually in the site where the hematomas had the shortest distance to the skin. And the site was usually away from the large blood vessels and functional areas, we performed a 3.0±1.1 cm straight vertical incision (**Figure 4**), drilled a 1.1±0.3 cm hole, cut in the shape of a cross in the endocranium and skin, then had an electrocoagulation hemostasis after the endoscope and the transparent conduit sheath were assembled, the puncture was performed visually. During the puncture, hematomas could be identified and the blood vessels could be avoided. Additionally, the hematomas margin and cavity were clearly visible after the puncture (**Figure 5**). We took out the neuroendoscope and the transparent conduit sheath tip, and then fix the transparent conduit sheath and placed the neuroendoscope into it so that we could evacuate the hematomas through the neuroendoscope working passage. First, most fragile hematomas were sucked and evacuated with the normal suction tube, and the tough hematomas were carefully cleared with hematoma smashing suction apparatus. The small bleeding could stop itself after the hematoma cavity was continuously washed by saline solution. The active bleeding could be stopped with endoscope-special bipolar coagulation or unipolar electroco agulation which connected the low current to the distal suction tube to conduct an electrocoagulation hemostasis. Most cases manifested effective hemostatic. The hematoma was carefully cleared under air condition and water condition alternatively until the surrounding brain tissues were exposed. The surrounding margins of the hematoma cavity could be identified under the transparent conduit sheath. The clearance degree of hematoma was handled properly: the dense clots closely connected with large vessels were not necessarily cleared. After the hematomas cavity was washed to the extent that no bleeding existed, we carefully withdrew the sheath, probed and cleared bleeding in the puncture passage. At last, we routinely indwelled an drainage tube, and closed the skull. (Attachment: **Figure 6**, cases of hypertensive cerebral hemorrhage in basal ganglia with PNET treatment).

Treatment, observation and follow-up after the operation: After the operation, the brain CT was rechecked and those cases with large amount of residual hematomas or with obstructed dr-

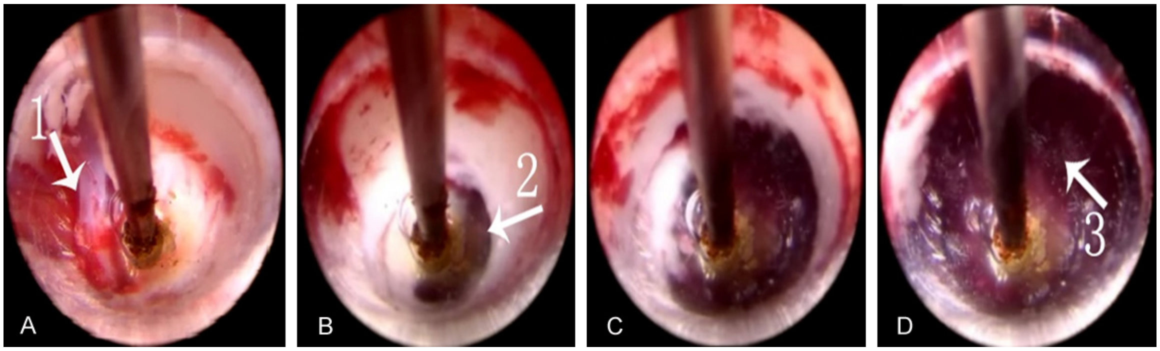

Figure 5. Visible hematahematoma puncture with PNET (A. Effectively avoding the big vessels during puncture (1). B. Entering the edge of the parenchymal hematoma (2). C. The endoscope carefully entering the the hematoma cavity. D. The endoscope entirely entering the the hematoma cavity (3) innerside).

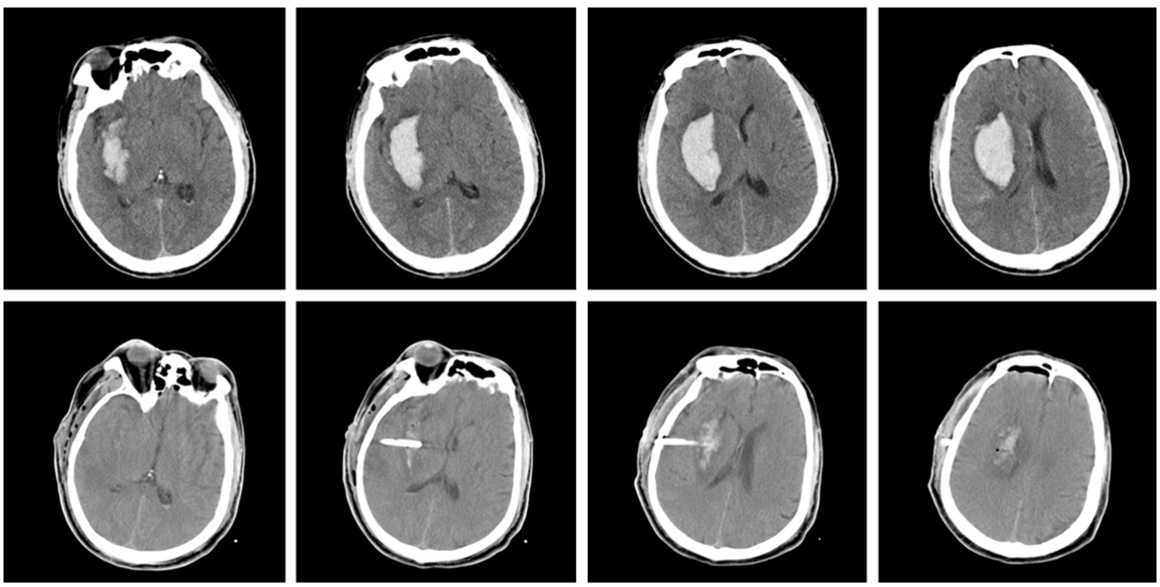

Figure 6. A 51 years old male case: the CT comparison between before and after PNET treatment in hypertensive cerebral hemorrhage in right basal ganglia.

ainage were administered with urokinase for drainage. Usage: 10,000 units of urokinase were injected into hematoma cavity; we kept the drainage pipes clamped closed for 2 hours and then opened them, these procedures were conducted twice daily; those patients with more than 80% of clearance rate had a brain CT check 48 hours later. The drainage tubes were removed in those with less than 10 ml hematomas. The nerve function and vital signs were closely observed in ICU. We kept the airway open and controlled the patients' blood pressure. Patients were treated with dehydration, hemostasis, lowering intracranial pressure. And each of these patients had a follow-up at 3 months after surgery, and had an GOS scale and CSI brain function monitor.

Results

The brain CT scan of 25 case after the surgery showed

The hematoma evacuation rate after PNET operation was 18 over 80%, 4 between 60% and 90% and 1 less than 60%. 1 case was converted to craniotomy for operation because of bleeding. The length of scalp incision was 3 to 4 cm with a mean of 3.0 cm, the diameter of bone window was 1.1 to 1.2 cm, the intraoperative blood loss was 40 to 100 ml with a mean of 50 ml, the operation time was 45 to 120 min with a mean of 65 min. Intracranial infection occurred after operation in 1 case which was cured with vancomycin injected through the lumbar cistern drainage sheath for 3 days; 6 cases using urokinase injection to treat residual hematoma. Posto perative stress ulcer and hemorrhage occurred in 3 cases; Pneumocephalus occurred in 6 cases. No hydrocephaly occurred. The Glasgow outcome scale (GOS) score 3 months after the operation revealed: recovered well in 3 patients, mild disability in 9, severe disability in 5 and no cases died. The Cerebral state Index (CSI) score 3 months after the operation revealed 81±7.8, significantly better than the preoperative ($P<0.05$).

Discussion

Neuroendoscopic technique has progressed rapidly. The operation indications has developed from the previous intraventricular lesions and cystic lesions to the brain parenchyma lesion; the hematoma evacuation under endoscope has become a new direction and hot spot. At present, comparing with them icroscopic surgery, endoscopy-guided removal of cerebral hemorrhage has much advantages in hematoma evacuation, such as short operation time, little hemorrhage volume, low complication rate, etc [7-9]; And its advantage was not only about smaller incisions, but also less injuries to the normal brain tissues during fistulation [10]. The deeper hematoma cavity could be clearly identified through the endoscope which could reduce the surgery bleeding, and improve the surgery effectiveness and safety. The endoscopy-guided removal of hematomas reported now was all endoscopy-guided surgery, which employed the view and light supplied by the neuroendoscope, and sucked out the hematomas by the suction apparatus outside of the neuroendoscope or conventional smashing suction apparatus; the surgery incision was about 4 cm, and bone window diameter was about 2-3 cm. Surgical entry was made through expander [11, 12]. The deficiency of the present endoscopy-guided surgery was listed below: the incision and bone window of the surgery was larger than that of PNET; ① The bone hole needed to be expanded by drilling to finish the surgery, and the brain damages brought about by the fistulation were larger than that of PNET. ② The catheter sheath was not mobile enough, which need a pair operation. The intracranial hematomas removal by PENT had smaller injuries and was mobile and easier to be popularized and applied.

The application of transparent conduit sheath and hematoma smashing suction apparatus

PNET in the treatment of intracerebral hemorrhage depended on large working channel endoscope neuroendoscope, transparent conduit sheath, hematoma smashing suction apparatus. The outside diameters of large working channel endoscope was 6.5 mm, the diameter of working channel was 3.7 mm, which could obtain clear images through digital magnification. The matching hematomas smashing suction apparatus could smashing the tough hematomas and clear them, which actually significantly improved hematoma clearance rate. The transparent conduit sheath which enabled the integration of the endoscope and the conduit sheath could reduce the surgery incisions, lessen the normal brain tissue injuries during the puncture and make operating with more flexible. For the enscope's own iron conduit sheathwas opaque, the puncturewas characterized with a certain degree of blindness. As the surgery progressed on, the hematoma was gradually sucked out. The hematomas center was difficult to locate. Incorrect locating could damage the surrounding normal vessels and brain tissues during the hematoma evacuation. With the transparent conduit sheath, endoscope could be guided to the hematoma location during the puncture. Under direct vision, it determined whether the hematoma was correctly punctured and the exact puncture depth, which could avoid the injury of important nerves and vessels. Meanwhile, the boundary between hematoma and normal tissue, the residual hematoma volume and location could be clearly identified. When the operative visual field was not clear, operation could go on in air condition, by sucking out the field's liquid and keeping operative field clear. Meanwhile the application of the PNET-specific version could improve the efficiency of hematoma clearance. Especially under the circumstances that the hematoma was too big or the operative time was too long, the superiority was more prominent. The suction force of the smashing suction apparatus could be manually controlled. The smashing suction apparatus could be opened when encountering the clot difficult to evacuate. The entire operation could be handled by a single operator. Besides, the inner axial of the smashing suction apparatus could be adjusted to a shorter length than the sheath, which could avoid the vessels injury caused by improper suction. The whole process was high secure.

PENT techniques

① we penetrated the needle to the cavity of hematoma, Under direct vision, the puncture depth should not be too deep or too shallow; the hematoma was evacuated from center outward. The bleeding-responsible vessels were mostly located around the hematoma, so marginal hematoma should be evacuated last. The clots adhering to the big vascular needed not evacuating forcibly. ② Only when the dark hematomas were clearly identified, could the evacuation be started, the white brain tissues could not be evacuated. Most hematomas could be evacuated quickly in the air condition. If the boundary between the hematoma and brain tissue was not clearly identified, the operative field could be washed in water condition to go on the evacuation. The author has realized that real-time adjusting the depth and angle of the transparent conduit sheath in the cavity of hematoma was secure. When we withdrew the sheath after the surgery, we could electrocoagulate bleeding sites in the puncture path. The postoperative CT revealed no puncture path bleeding. ③ After the operation preparation, we routinely washed the hematoma cavity; checked out whether there is bleeding or residual hematoma under water condition. Small bleeding could stop after the hematomas cavity wascontinuously washed by saline solution. The active bleeding could be stopped with endoscope-special bipolar coagulation or unipolar electrocoagulation which connected the low current to the distal suction tube to conduct an electro-coagulation hemostasis. Most manifested an effective hemostatic. ④ This technique could better distinguish the hematoma and brain organization. Only 1 case with uncontrolled bleeding during operation needed craniotomy treatment. The remaining cases went well, The reasons for this results were poor experience of early surgery, too fast evacuation, forcefully evacuation cots adhering to the vessels. Most of the cases with less than 80% of hematoma clearance were in the early stage of PENT. ⑤ The treatment of the postoperative residual hematoma: We routinely placed drainage tube hematoma cavity after the surgery. and most tubes were withdrawn within 48 hours. The effects of urokinase injection was prominent if the residual hematoma was large.

The deficiency and improvement of PENT

Through the analysis of cases, the author realized the deficiency of the technique, such as: stereoscopic effect was lacking; airflows frequently blurred the lens during the operation. In order to keep their vision clear, the suction tube orifice and the distal suction tip should not be blockedunder the condition that the evacuation was not affected. The suction force handling of the suction apparatus required further study, lest the normal brain tissue was damaged with too much suction force. Massive haemorrhage in the operation was difficult to deal with through PENT; otherwise, under air condition, intracranial pressure reduced after the hematoma evacuation and then the air went into the vacuum subdurale and the hematoma cavity, which could cause the postoperative intracranial pneumatosis. 6 cases with postoperative pneumocephalus occurred. Therefore air removal and water injection into the hematoma cavity and subdural space after the operation was very important. The technique key points needs further improvement: the determination of the suction force in different phase needs the development of transparent, nontoxic hemostasis flushing fluid and mobile fixator of transparent conduit sheath designed for single operation, etc.

Cerebral state index (CSI)

CSI was obtained through UP-8000 cerebral state monitor (the handset was provided by Danmeter AS Ltd, Denmark, the mainframe was provide by anesthesia depth lab of Shenzhen Creative Industry Co.,Ltd. The company was listed and registered in Shenzhen science and technology bureau). The instrument got patients' Spontaneous EEG through electrodes connected the patient's forehead and temple and mastoid behind ear and quantified the patient's level of consciousness and brain function thorough fuzzy logic state analyzer. A previous study [13] showed that in the unconscious patients with brain damage, as scale range meaning from consciousness to deep coma and to brain death, CSI 0-100 was positively correlated with coma score of GCS, brain stem reflection, auditory evoked potential index, deep and shadow reflection, and could reflect real time coma depth and the coma dynamic process accurately. This study found that the whole brain function states had obvious improvement in 3 months of postoperative follow-up comparing with the preoperative state (P<0.05).

In summary, authors believed that PNET conformed to the mini invasive neurosurgical technique development direction and reached the goal to have lest trauma to get the best surgery effect. It is a new acceptable technique of convenient operation, small trauma, high evacuation rate and being easy to popularize. The continued perfection of this technique could enable the technique applied in to the treatment of the brain parenchymatous and the ventricular tumors and this technique has a board perspective.

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Disclosure of conflict of interest

None.

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