Research Article

https://doi.org/10.23934/2223-9022-2022-11-1-22-30

Endoscopic Removal of Acute Traumatic Intracerebral Hemorrhage

I.M. Godkov[1], A.E. Talypov[1], V.V. Krylov[1, 2], A.A. Grin[1, 2], V.G. Dashyan[1, 2], M.Yu. Savvin[1] ✉

Department of Neurosurgery
[1] N.V. Sklifosovsky Research Institute for Emergency Medicine
3 B. Sukharevskaya Sq., Moscow, 129090, Russian Federation
[2] A.I. Yevdokimov Moscow State University of Medicine and Dentistry
20, bldg. 1 Delegatskaya St., Moscow 127473, Russian Federation

✉ **Contacts:** Mikhail Yu. Savvin, Clinical Resident of the Emergency Neurosurgery Department, N.V. Sklifosovsky Research Institute for Emergency Medicine.
Email: doctorlothbrock@gmail.com

ABSTRACT Nowadays surgical treatment of patients with traumatic intracranial hematoma (TICH) and injuries of the brain is a very actual problem in neurosurgery.

The purpose of this work was to assess of the feasibility and safety of minimally invasive endoscopic removal of TICH.

MATERIAL AND METHODS In the period of 2010–2019, 2734 operations were performed on patients with traumatic brain injury in the Sklifosovsky Research Institute. There were 334 patients with TICH and the CC/BC foci, that made 12.2% of all patients. The median of hematoma volume, that did not cause a loss of consciousness was 48 cm2, and in most of the patients the hematoma volume ranged 30–35 cm^2. Local fibrinolysis of TICH was performed in 14 patients with the hematoma volume of 30–50 cm^2 without brain dislocation and not causing the consciousness depression more severe than sopor.

Endoscopic removal of TICH was performed in 4 men at mean age of 54.8 years within 18–36 hours after trauma. Three patients had depression of consciousness to obtundation (14 by Glasgow Outcome Scale (GCS)), and one patient was in clear consciousness. The volume of the dense part of the contusion foci in the pole-basal regions of the frontal and temporal lobes was 24–40 cm^3.

RESULTS Among patients with TICH operated on by using the traditional technique, postoperative lethality was 13%, good outcomes were seen in 41%, and 46% had neurological disorders of varying severity. While treating the patients with TICH by using the local fibrinolysis method, 1 patient died after surgery, a good outcome was seen in 8 of 14 patients, and neurological disorders persisted in 3 patients in the postoperative period.

Radicality of surgery in patients operated on by using endoscopic technique averaged 76% ranging from 41% to 91%. There were no complications during surgery nor in post-operative period. Patients were discharged from hospital after 8-21 days.

Keywords: traumatic intracerebral hemorrage, cerebral contusion, endoscopy

For citation Godkov IM, Talypov AE, Krylov VV, Grin AA, Dashyan VG, Savvin MYu. Endoscopic Removal of Acute Traumatic Intracerebral Hemorrhage. *Russian Sklifosovsky Journal of Emergency Medical Care*. 2022;11(1):22–30. https://doi.org/10.23934/2223-9022-2022-11-1-22-30 (in Russ.)

Conflict of interest Authors declare lack of the conflicts of interests

Acknowledgments, sponsorship The study has no sponsorship.

Affiliations

Ivan M. Godkov	Candidate of Medical Sciences, Senior Researcher of the Emergency Neurosurgery Department, N.V. Sklifosovsky Research Institute for Emergency Medicine, Moscow Health Department; https://orcid.org/0000-0001-8651-9986, i.godkov@yandex.ru; 40%, making neurosurgical interventions, reviewing the literature on the topic of the article, analyzing the data, writing the text of the manuscript
Alexander E. Talypov	Doctor of Medical Sciences, Researcher of the Emergency Neurosurgery Department, N.V. Sklifosovsky Research Institute for Emergency Medicine; http://orcid.org/0000-0002-6789-8164, dr.talypov@mail.ru; 20%, literature review, data analysis, writing the text of the manuscript
Vladimir V. Krylov	Doctor of Medical Sciences, Academician of the Russian Academy of Sciences, Chief Researcher of the Department of Emergency Neurosurgery of the N.V. Sklifosovsky Research Institute for Emergency Medicine, Moscow Health Department, Head of the Department of Neurosurgery and Neurocritical Care, A.I. Evdokimov Moscow State University of Medicine and Dentistry; http://orcid.org/0000-0001-5256-0905, manuscript@inbox.ru; 10%, data analysis, scientific editing
Andrey A. Grin	Doctor of Medical Sciences, Head of the Emergency Neurosurgery Department of the N.V. Sklifosovsky Research Institute for Emergency Medicine, Moscow Health Department, Professor of the Department of Neurosurgery and Neurocritical Care, A.I.Evdokimov Moscow State University of Medicine and Dentistry; http://orcid.org/0000-0003-3515-8329, aagreen@yandex.ru; 10%, data analysis, scientific editing

Vladimir G. Dashyan	Doctor of Medical Sciences, Professor of the Department of Neurosurgery and Neurocritical Care, A.I. Evdokimov Moscow State University of Medicine and Dentistry; https://orcid.org/0000-0002-5847-9435, v485@bk.ru; 10%, making neurosurgical interventions, reviewing the literature on the topic of the article, analyzing the data, writing the text of the manuscript
Mikhail Yu. Savvin	Clinical Resident of the Emergency Neurosurgery Department, N.V. Sklifosovsky Research Institute for Emergency Medicine; https://orcid.org/0000-0003-3958-2821, doctorlothbrock@gmail.com; 10%, literature review, data analysis

CC, cerebral contusion
CT, computed tomography
DM, dura mater
EMS, emergency medical system
GCS, Glasgow Coma Scale
GOS, Glasgow Outcome Scale
ICH, intracerebral hemorrhage

INTRODUCTION

Surgical treatment of patients with the brain contusion foci of limited volume is an urgent problem in the light of the use of modern technologies and minimally invasive surgery [1, 2]. Most of the brain contusions are localized in the frontal and temporal lobes, i.e. in functionally significant areas. To remove lesion localized in the brain parenchyma, as a rule, bone-plastic or resection trepanation of the skull is performed and the bruise focus is removed through an encephalotomy opening. Even the use of an operating microscope and microsurgical equipment does not always allow making a revision of the hematoma cavity and achieving high-quality hemostasis. Among operations for traumatic brain injury (TBI), the proportion of brain contusions ranges from 12% to 17%. Volume of traumatic intracerebral hematoma (TICH) in the majority of patients undergoing surgery was 15-60 cm3. Many patients with a small hematoma volume usually have no brain compression, nor rapidly progressive dislocation syndrome, or intracranial hypertension, but the growing focal neurological symptoms force the surgeon to perform a surgical treatment.

The aim of our work was to clarify the feasibility and safety of minimally invasive endoscopic removal of TICH.

MATERIAL AND METHODS.

In the period from 2010-2019, 2,734 patients received surgical treatment for traumatic brain injury in the N. V. Sklifosovsky Research Institute of Emergency Medicine. There were 334 patients with traumatic intracerebral hematoma and foci of brain contusion, which accounted for 12.2% of all operated patients. The median age of patients operated on for traumatic intracerebral hematoma was 42.5 years. Of the 334 operated patients, 284 were men and 50 were women (85% and 15%, respectively). The volume of the lesion was 18-230 cm3 (Fig. 1)

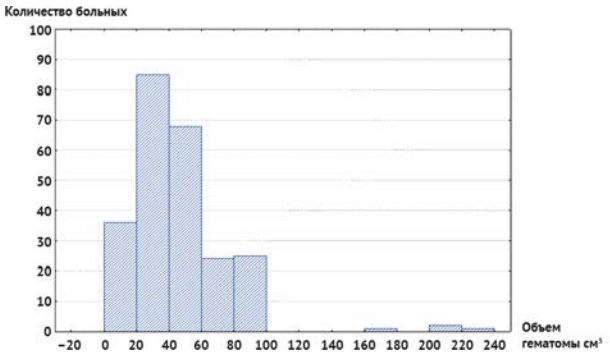

Fig. 1. The volume of traumatic intracerebral hemorrhage (n=334)

Note: – Number of patients

– Hematoma volume

As seen from Fig. 1, the hematoma volume did not exceed 100 cm3 in most patients. In 175 patients, the volume of intracerebral hematoma did not exceed 40 cm3. Sixty seven per cent of the patients were still conscious before the operation (Fig. 2).

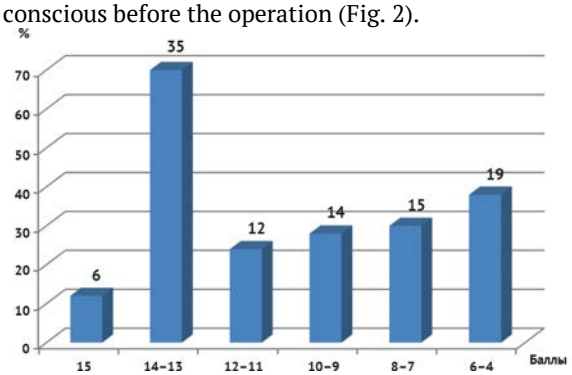

Fig. 2. The level of patient consciousness before surgery (n=334)

There was a correlation between the volume of TICH and the level of consciousness before surgery. Of 175 patients with a TICH volume of less than 40 cm3, 75% had no consciousness impairments or they were reduced to obtundation (Fig. 3). The median hematoma volume with which patients had no consciousness impairments was 48 cm3, and in most patients the hematoma volume was in the range of 30-50 cm3.

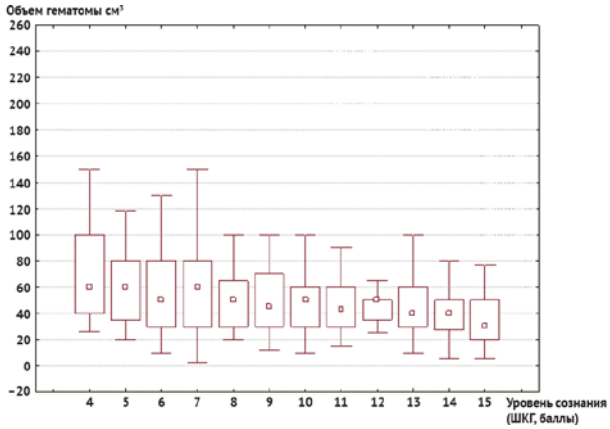

Fig. 3. The volume of intracerebral hemorrhage with regard to level of consciousness before surgery (n=334)

Note: – Number of patients

– Hematoma volume

Nineteen per cent of patients with TICH had mydriasis on the contralateral side. Patients with TICH developed hemiparesis more often than patients with other types of injuries: 132 of 334 operated patients (40%).

Among patients with ICH, late (bridge and mid-brain) stages of dislocation syndrome were present in 27%, initial (early-diencephalic and late-diencephalic) stages of dislocation were present in 32% of patients. There was no brain stem dislocation in 38% of patients with ICH. The median volume of TICH without computed tomography (CT) signs of basal cistern compression was 38 cm3 [22; 55].

Local fibrinolysis of traumatic hematoma was performed in 14 patients. Fibrinolysis was performed in patients with a lesion volume of 30 to 50 cm3 causing no gross brain dislocation, and clinically not being associated with the depression of consciousness deeper than sopor (scored 9 and higher by Glasgow Coma Scale).

Fibrinolysis was performed with recombinant prourokinase. The volume of hematoma in patients who underwent fibrinolysis was 20-46 cm3. The mean open surgery time in patients with TICH was 174 minutes [45; 390]. Median time for puncture and hematoma drainage for subsequent local fibrinolysis in patients with TICH was 40 minutes [25; 110]

Endoscopic removal of TICH was performed in 4 patients. All of them were men at mean age of 54.8±16.5 years. The patients were delivered to the Institute's Emergency Department by ambulance teams within 18 to 48 hours after the injury. In 3 cases, the cause of the injury was a fall from a height of one's own in a state of alcoholic intoxication, and a criminal injury in 1 case. Three patients had depressed consciousness to obtundation (scored 14 by Glasgow Outcome Scale [GOS]), one patient had clear consciousness. There were focal neurological symptoms in all patients: mental disorders in 1 patient, motor aphasia and hemiparesis scored 4 in 1 case, sensorimotor aphasia in 1, and primary generalized episeizures in 1 patient.

The injuried had brain contusion foci (of type 3 according to V. N. Kornienko classification) located in the polar-basal parts of the frontal and temporal lobes [3]. The volume of brain contusion foci ranged from 63 to 93 cm3, the volume of the dense part of the TIVH was from 24 to 40 cm3, and the dislocation of the median structures was in the range of 2 to 5 mm.

Patients underwent surgery in the next few hours after hospital admission. The operation consisted of endoscopic removal of an ICH through trephination burr holes of 15-20 mm in diameter performed under the frameless neuronavigation guide. During surgical procedure, an endoscope and a Gaab (Storz) trocar and a 4-mm diameter endoscope for direct visualization (Karl Storz, Germany) designed for endonasal surgery were used together with a transparent cannula originally designed for endoscopic surgery for ICH and manufactured at the Medsil Plant (Fig. 4). After surgery, control CT scans of the brain were obtained within the next 6 hours. The results of treatment were evaluated at 1 month after surgery using GOS [4].

Fig. 4. A transparent cannula with a diameter of 8 mm and a length of 10 cm with a beveled distal end for the removal of subcortical intracerebral hemorrhage

RESULTS

Among patients with TICH who underwent traditional surgery, a postoperative mortality was 13%, 41% of patients had good outcomes, and 46% had neurological disorders of varying severity.

When the patients with TICH were treated by using local fibrinolysis, 1 patient died after surgery, 8 of 14 patients had a good outcome, and 3 patients had neurological disorders in the postoperative period.

In the patients who underwent endoscopic surgery, the radicality of operations averaged 76% (ranging from 41% to 91%). The least effective intervention was the first one in chronological order, during which only 41% of clots were removed. In subsequent operations, the radicality of ICH removal was 85-91% (Table 1).

Table

Characteristics of patients and surgery

No.	Age	Localization of the CC focus	Volume of CC focus, cm3	mGCS	Focal symptoms	Timing of surgery	Surgery duration	Residual ICH volume	GOS
1	54	Frontal lobe	39/64	9	Mental disorders	4	110	23/44	4
2	78	Frontal lobe	24/63	9	Aphasia, hemiparesis	3	60	3/60	4
3	40	Temporal lobe	34/47	10	Episyndrome	3	85	3/32	5
4	47	Temporal lobe	40/93	9	Aphasia	2	70	6/63	4

Notes: ICH — intracerebral hematoma; CC — cerebral contusion; GOS — Glasgow Outcome Scale; mGCS — modified Glasgow Coma Scale

There were no complications during operations nor in the postoperative period. After the extubation on the first day after surgery and completed intensive care at 1-2 days, the patients were transferred to the Neurosurgery Department and later discharged from hospital within 8 to 21 days.

Clinical case report No. 1

Patient R., 47 years old, was delivered to the N. V. Sklifosovsky Research Institute of Emergency Medicine by the ambulance team; he was found in the street with traces of trauma on his head. Condition at admission was of moderate severity. The smell of alcohol from the mouth was determined. Level of consciousness was determined as moderate obtundation. Moderate meningeal syndrome. Sensorimotor aphasia. Pupils were of 2.5 mm in diameter, photoreaction was reduced. There were no oculomotor disorders. The face was symmetrical. There were no bulbar disorders. There was no paresis. Soft tissue swelling in the right temporal and occipital regions was determined locally. Cerebral CT revealed a linear fracture of the right temporal and occipital bones with the involvement of skull base, the focus of the contusion was a crush of the right temporal lobe with a total volume of 93 cm3 (dense part up to 78 NU – 40 cm3), small focal injury of the right frontal lobe 1.5 cm3, a 3 mm transverse dislocation of midline structures to the left (Fig. 5).

Fig. 5. Brain computed tomography scan of patient R., 47 years old, on admission at the hospital

Due to the fact that the patient had a 40/93 cm3 contusion of the temporal lobe, sensorimotor aphasia, it was decided to choose a surgical treatment. Considering that the patient had moderate cerebral symptoms, a slight compression of the bypass cistern, and the bruise focus was mainly represented by a high-density component (type 3 according to V. N. Kornienko), the decision was taken to remove the hemorrhagic part of the contusion focus by endoscopic aspiration.

Surgery progress

The patient's head was fixed in a Mayfield scull clamp, and registered in the frameless neuronavigation system. A transparent endoscopic cannula of 8 mm in diameter was also registered in the navigation system. A vertical skin linear incision of 4 cm long was made in the right temporal region immediately above the zygomatic arch and 1 cm anterior from the tragus. A burr hole was made and expanded to 17-18 mm in diameter and additionally enlarged by the resection of the inner lamina of the bone at an angle. After a cruciate incision of the dura mater (DM), the intracerebral hematoma was punctured using a transparent endoscopic cannula. After removing the stylet, a small amount of the ICH liquid fraction discharged through the cannula. A 4 mm direct-vision endoscope and the tip of a vacuum aspirator were inserted into the port through which the liquid part of ICH and clots of different densities were removed (Fig. 6). By the end of the operation, the brain sank into the trephination window and pulsates well. Final hemostasis was achieved using Surgiflo that was washed with saline solution. The DM reconstruction was performed using a Tachocomb, the temporal muscle and soft tissues were sutured in layers.

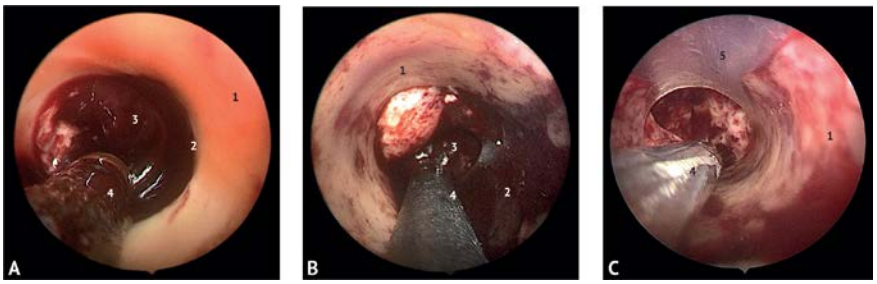

Fig. 6. Intraoperative photography. Aspiration of intracerebral hemorrhage through a transparent port, view through an endoscope: A — at the beginning of clot removal; B — during clot removal; C — at the end of the main stage of the operation.

Note: 1 — white matter of the brain; 2 — blood clots behind the wall of the transparent port, 3 — blood clots in the lumen of the port, 4 — the tip of the vacuum aspirator, 5 — a clot-free cavity behind the port wall after the intracerebral hemorrhage removal

The course of the postoperative period was uneventful. The CT of the brain performed at 3 hours after surgery showed a 85% removal of the hemorrhagic part of the contusion lesion in the right temporal lobe (6 cm3 hemorrhagic component still remained), pneumocephaly in the fronto-temporal region, the transverse dislocation of the median structures 5 mm to the left (Fig. 7). At 2 days after surgery, the patient's condition improved; a gradual regression of aphasia and cerebral symptoms were noted. The surgical wound was healed by primary tension. After the sutures were removed, the patient was discharged from hospital in a satisfactory condition and with a good recovery (GOS-5).

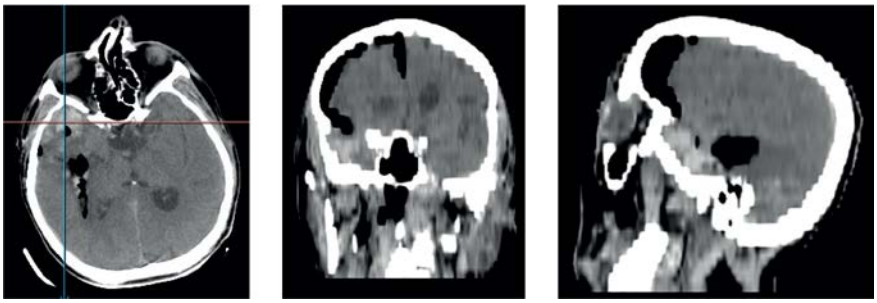

Fig. 7. Brain computed tomography of patient R., 47 years old, after surgery

Clinical case report No. 2

Patient Kh., 40 years old, was admitted at the N. V. Sklifosovsky Research Institute for Emergency Medicine by EMS ambulance team 20 hours after the head injury. Upon admission, he complained of severe headache, nausea, and repeated vomiting. From the medical history, it became known that the patient suffered from epilepsy. The head injury occurred during the development of a primary generalized convulsive seizure and falling backwards. At the time of hospital admission, the patient's condition was moderately severe. Level of consciousness was characterized as moderate obtundation; scored 14 by GCS. Moderate meningeal syndrome. There were no focal neurological disorders. Soft tissue swelling in the occipital region were determined locally. Cerebral CT verified a limited focus of contusion (type 3 by V.N.Kornienko) in the right temporal lobe (hemorrhage volume 34 cm3) with a small perifocal edema, small focal contusion (2 cm3)of the left frontal lobe, acute subdural hematoma of 10 cm3 in the right temporal region, transverse dislocation of the median structures 5 mm to the left (Fig. 8).

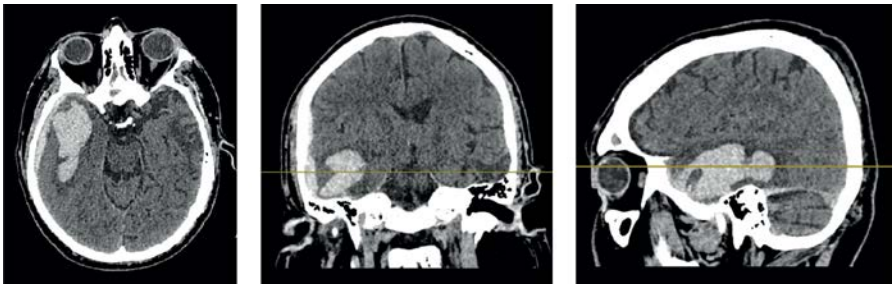

Fig. 8. Brain CT scan of patient H., 40 years old, on admission at the hospital

Taking into account the depressed consciousness to obtundation, the volume and type of the right temporal lobe contusion focus, and the brain dislocation, the patient underwent emergency surgery of endoscopic removal of an intracerebral hematoma (about 30 cm3) in the right temporal lobe.

Surgery progress.

The patient's head was fixed in a Mayfield scull clamp and registered in the frameless neuronavigation system. A vertical linear skin incision 4 cm long was made in the right temporal region immediately above the zygomatic arch and 1 cm anterior to the tragus. A burr hole was made in the sheath of the temporal bone of 15 mm in diameter. After a cruciate incision of the DM and removal of the subdural hematoma part in the projection and around the burr hole, the hematoma of the right temporal lobe was punctured with a Gaab trocar (6.5 mm) previously registered in the frameless neuronavigation system. An endoscope, and a flexible tip of a vacuum aspirator (14G) were inserted into the trocar, and ICH was removed by alternating aspiration of blood clots and irrigation of the cavity under visual control and under the neuronavigation guide (Fig. 9A, B). Final hemostasis was achieved by washing the ICH cavity with warm saline solution for 5 minutes (Fig. 9C). DM was reconstructed using a Tachocomb. Soft tissues were sutured in 3 layers. The blood loss was minimal. The surgery duration was 85 minutes.

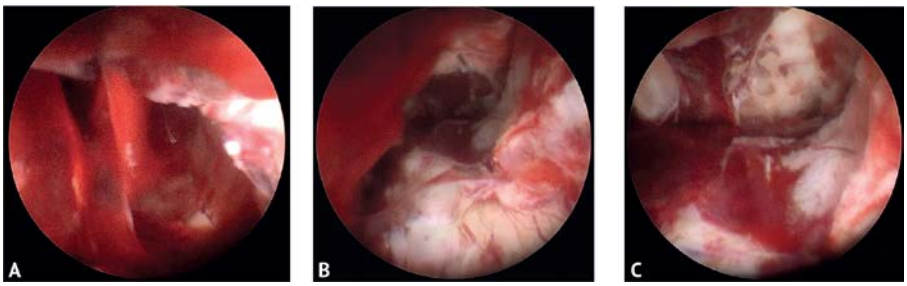

Fig. 9. The view via the endoscope 00: the ICH cavity at the stage of the removal of parietal clots and the final hemostasis

Control CT was performed at 2 hours after surgery, the intracerebral hematoma was completely removed, and the dislocation of the median structures decreased to 3 mm (Fig. 10). No complications occurred in the postoperative period. A day later, the patient's consciousness was restored and became clear (scored by GCS); thanks to undertaken anticonvulsant therapy, no seizures repeated. He was discharged on day 10 in satisfactory condition (GOS-5).

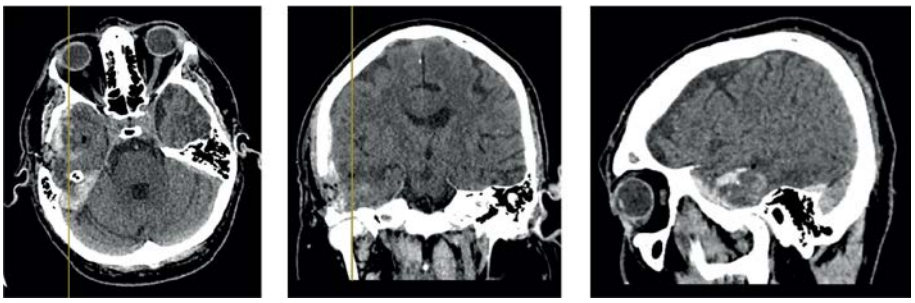
Fig. 10. Brain CT of patient H., 40 years old, 2 hours after endoscopic removal of the ICH of the right temporal lobe

DISCUSSION

Traumatic ICH hematomas account for a significant proportion among the patients operated on for traumatic brain injury. Traditional tactics of surgical treatment of patients with TICH and CC foci involve the skull trepanation, performing encephalotomy, and removing the focus of brain lesion. Indications for surgical treatment in patients with TICH include depressed consciousness, focal neurological symptoms, and the risk of brain dislocation [5, 6, 7, 8]. According to the data from the N. V. Sklifosovsky Research Institute for Emergency Medicine, the median total ICH volume in patients undergoing surgical treatment was 44 cm3 [65 cm3, 29 cm3]. All patients with an ICH volume exceeding 37 cm3 were operated. The median total hematoma volume in patients undergoing conservative treatment was 16 cm3, and the upper quartile of hematoma volume was 25 cm3.

The majority of patients with TICH undergo osteoplastic skull trepanation. In some patients, developing brain edema forces the surgeon to perform decompressive skull trepanation. The study conducted at our Institute made it possible to define the criteria for performing preventive cranial trepanation in the injuried with traumatic ICH: a level of consciousness scored 7 or lower by GCS, a hematoma volume of 55 cm3, a lateral dislocation of more than 6 mm, and a ventricular-cranial coefficient 2 (VCC-2) of less than 9% [7].

In patients with TICH who do not require decompressive trepanation, minimally invasive surgery that involves endoscopic hematoma removal and local fibrinolysis can show the best functional treatment outcomes.

The first studies demonstrating the feasibility of endoscopic TICH removal belong to L.M. Auer et al. (1988) and V. B. Karakhan et al. (1994) [9, 10]. L.M. Auer et al. (1988) used rigid endoscopes and the technique of irrigating the blood clots by pumping and actively aspirating fluid through the working channels of the trocar to remove ICH. V. B. Karakhan et al. (1994) used a fibroscope for these operations, and the main method of removing clots was their direct aspiration through the working channel of the endoscope [10]. Subsequently, for two decades, there were no reports of endoscopic surgery for traumatic ICH. In the search query, we have managed to find only three studied over the recent 10 years, representing the total experience

of treating 13 patients with TICH [5, 6, 11]. In all cases, during the operations performed through the trephination burr holes, the ICH removal was performed under the rigid endoscope guidance.

In our case series, all patients remained conscious; and the indications for surgery included episyndrome in 1 patient, aphasia in 1, mental disorders in 1, aphasia and hemiparesis in one more patient. M. Mino et al. (2019), presenting the largest series of patients, performed such operations in patients with a level of consciousness from coma to deep obtundation and the criterion for surgery indication was an acute dislocation syndrome [6]. Other reports on endoscopic surgery for CCs, describe only isolated cases [5, 11], or give a brief description of patients without detailed information [9, 10]. Despite the fact that M. Mino et al. (2019) operated on some patients even with signs of advanced dislocation syndrome, the authors obtained generally good results: 40% of favorable outcomes, 40% of severely disabled patients, and 20% of unfavorable outcomes as assessed by GOS. Thus, the outcomes of open surgery and endoscopic surgery are comparable. In our study, all patients operated on using neuroendoscopy achieved outcomes scored by GOS 4-5, apparently due to the fact that the operations were performed on time, before the development of dislocation syndrome.

Local fibrinolysis is also an effective method of surgery for TICH. The disadvantages of this method include limitations for using fibrinolytics in some patients, the possibility of systemic effect of the drug, and the risk of an increase in the ICH volume. Currently, there are no medications approved for use via the intrathecal route in Russia.

SPECIFIC FEATURES OF SURGICAL TECHNIQUES

To remove ICH, we used a Gaab ventriculoscope paired with a metal trocar, or an endoscope for transnasal surgery and a transparent endoscopic cannula of 8 mm in diameter. Blood clots were removed from the brain substance in the following way: by using both the Gaab trocar and the transparent cannula, the liquid blood and clots were first aspirated using the flexible tip of a vacuum aspirator, then the cavity was irrigated with warm saline solution. It made possible to achieve hemostasis of small diffuse hemorrhage from the walls and to inspect the cavity for the presence of residual clots. In operations using a transparent cannula, the endoscopic picture during the intervention was more informative: the transparent walls of the cannula allowed visualizing the clots and brain matter both in the port lumen and around, which made the work more convenient and improved orientation. A distinguished characteristic of the transparent cannula we used during operations was the beveled distal end, which increased the efficacy of manipulating with the tip of the vacuum aspirator when removing blood clots, allowing faster and easier removal of clots located outside the axis of surgical access (Fig. 4).

The liquid part of ICH and loose clots were well removed through the lumen of the flexible and rigid tips of the vacuum aspirator; dense clots were removed through the lumen of the trocar and endoscopic cannula. There was no significant bleeding during surgery. We were ready to achieve hemostasis with liquid hemostatic agents, or with endoscopic monopolar electrodes, but the use of electrocoagulation was not necessary in any case. At the completing stage, the final hemostasis was achieved by abundant irrigation with warm saline solution for 2 minutes, or administering one of liquid hemostatics (Hemoblock, Surgiflo).

No cerebral edema was seen during surgery in any of the cases. After removing the blood clots, the brain remained behind the trepanation window, which indirectly indicated the achievement of a decompression effect. Due to that and taking into account that the patients were clearly conscious or in obtundation prior to surgery, no invasive ICP measurements were performed.

There were no postoperative complications in the patients presented in this study. In the studies of other authors, we found no complications associated with endoscopic TICH removal, either [5, 9, 10, 11].

Given the uneventful postoperative course in patients of our small group and no complications, we consider the use of endoscopic techniques for the TICH removal to be justified and promising in a certain group of patients, namely in patients with limited contusion foci accompanied with focal neurological symptoms.

CONCLUSION

Endoscopic removal of traumatic intracerebral hematomas through mini-accesses is an effective and safe technique and can be a reasonable alternative to traditional craniotomy in patients who do not require decompressive cranial trepanation.

REFERENCES

1. Zhang S, Qian C, Sun G, Li X. Clinical application of the supraorbital key-hole approach to the treatment of unilateral-dominant bilateral frontal contusions. *Oncotarget*. 2017;8(29):48343–48349. PMID: 28415664 https://doi.org/10.18632/oncotarget.15983
2. Marklund N. Neuroendoscopy-a minimally invasive alternative in the surgical management of traumatic intracerebral contusions? *Acta Neurochir (Wien)*. 2019;161(2):231–232. PMID: 30666452 https://doi.org/10.1007/s00701-019-03813-8
3. Kornienko VN, Pronin IN. Diagnosticheskaya neyroradiologiya. Moscow; 2006. (in Russ.)
4. Jennett B, Bond M. Assessment of outcome after severe brain damage: A practical scale. *Lancet*. 1975;1(7905):480–484. PMID: 46957 https://doi.org/10.1016/s0140-6736(75)92830-5
5. Tamura R, Kuroshima Y, Nakamura Y. Neuroendoscopic Removal of Acute Subdural Hematoma with Contusion: Advantages for Elderly Patients. *Case Rep Neurol Med*. 2016;2016:2056190. PMID: 26981295 https://doi.org/10.1155/2016/2056190
6. Mino M, Fujimura M, Yoshida M, Sonobe S, Tominaga T. Application of neuro-endoscopic target aspiration of the necrotic core for cerebral contusion with delayed progression: technical note. *Acta Neurochir (Wien)*. 2019;161(2):225–230. PMID: 30515614 https://doi.org/10.1007/s00701-018-3753-z
7. Krylov VV, Talypov AE, Levchenko OV. (eds.) *Khirurgiya tyazheloy cherepno-mozgovoy travmy.* Moscow: ABV-press Publ.; 2019. (in Russ.)
8. Franke CL, van Swieten JC, Algra A, van Gjin J. Prognostic factors in patients with intracerebral hematoma. *J Neurol Neurosurg Psychiatry*. 1992;55(8):653–657. PMID: 1527534 https://doi.org/10.1136/jnnp.55.8.653
9. Auer LM, Holzer P, Ascher PW, Heppner F. Endoscopic neurosurgery. *Acta Neurochir (Wien)*. 1988;90(1–2):1–14. PMID: 3278501 https://doi.org/10.1007/BF01541260
10. Karakhan VB, Khodnevich AA. Endoscopic surgery of traumatic intracranial haemorrhages. *Acta Neurochir Suppl.* 1994;61:84–91. PMID: 7771231 https://doi.org/10.1007/978-3-7091-6908-7_15
11. Nascimento CN, Amorim RL, Mandel M, do Espírito Santo MP, Paiva WS, Andrade AF, et al. Endoscopic-assisted removal of traumatic brain hemorrhage: case report and technical note. *J Surg Case Rep*. 2015;2015(11):rjv132. PMID: 26537390 https://doi.org/10.1093/jscr/rjv132
12. Krylov VV, Burov SA, Galankina IE, Dashyan VG. Local Fibrinolysis in the Surgery of Intracranial Hemorrhages. *Russian journal of neurosurgery*. 2006;(3):4–12. (in Russ.)

Received on 02.02.2021

Review completed on 23.12.2021

Accepted on 27.12.2021