ISSN 2313-8254 (English ed. Online)
ISSN 0042-8817 (Russian ed. Print)
ISSN 2309-1681 (Russian ed. Online)

PROBLEMS OF NEUROSURGERY

NAMED AFTER N.N. BURDENKO

№2 ⁕ 2015 ⁕ vol. 79
Founded in 1937.

Media Sphera

ISSN 2313-8254 (English ed. Online)
ISSN 0042-8817 (Russian ed. Print)
ISSN 2309-1681 (Russian ed. Online)

Burdenko Neurosurgical Institute, Moscow, Russia

PROBLEMS OF NEUROSURGERY

named after N.N. Burdenko

Vol. 79 **2'2015**

FUNDAMENTAL AND PRACTICAL JOURNAL

«Zhurnal voprosy neirokhirurgii imeni N N Burdenko» (Problems of Neurosurgery named after N.N. Burdenko) is a bimonthly peer-reviewed medical journal published by **MEDIA SPHERA Publishing Group. Founded in 1937.**

Journal is indexed in **RSCI (Russian Science Citation Index), PubMed/Medline, Index Medicus, Scopus/EMBASE, Chemical Abstracts, Ulrich's Periodicals Directory, Google Scholar.**

MEDIA SPHERA Publishing Group:
Dmitrovskoe sh. 46-2, Moscow,
127238 Russia
Tel. +7 (495) 482 4329
Fax: +7 (495) 482 4312
E-mail: info@mediasphera.ru
www.mediasphera.ru

Correspondence address:
Moscow, P.O. Box 54, 127238 Russia
Media Sphera
Advertising department: +7 (495) 482 0604
E-mail: reklama@mediasphera.ru
Subscription department: +7 (495) 482 5336
E-mail: zakaz@mediasphera.ru

Address of the editorial office:
4-ya Tverskaya-Yamskaya ul., 16,
Moscow, 125047
Russia
Burdenko Neurosurgical Institute
Tel. +7 (499) 972 8566
E-mail: VIvannikova@nsi.ru
Managing Editor
V.K. Ivannikova

Art and Layout: MEDIA SPHERA Publishing Group

Knopov M.Sh., Taranukha V.K.
Russian Field Neurosurgery: Historical Milestones (on the Occasion of the 70th Anniversary of Victory in the Great Patriotic War) 3

ORIGINAL ARTICLES

Ryzhova M.V., Shishkina L.V.
Molecular Methods in Diagnosis of Poorly Differentiated Malignant Brain Tumors in Children 7

Pedachenko E.G., Biloshytsky V.V., Mikhal'sky S.A., Gridina N.Ya., Kvitnitskaya-Ryzhova T.Yu.
The Effect of APOE3 Gene Therapy on Structural and Functional Manifestations of Secondary
Hippocampal Damages in Experimental Traumatic Brain Injury. 17

Goryaynov S.A., Potapov A.A., Ignatenko M.A., Zhukov V.Yu., Protskiy S.V., Zakharova N.A., Okhlopkov V.A., Shishkina L.V.
Glioblastoma Metastases: a Literature Review and a Retrospective Analysis of Six Cases 28

Kadasheva A.B., Cherekaev V.A., Shifrin M.A., Kozlov A.V., Gol'bin D.A., Tsukanova T.V., Galkin M.V., Belov A.I., Radchenkov N.S.
Quality of Life in Patients with Benign Tumors of the Anterior and Middle Skull Base after Surgery and during Follow-Up 38

Muin R., Magomedov R.K., Tsuladze I.I.
Clinical Diagnostic Features of Surgical Treatment for Thoracic Outlet Syndrome. 49

Simernitskiy B.P., Petraki V.L., Prityko A.G., Asadov R.N., Azamov D.D., Klimchuk O.V., Prokop'ev G.G.,Ishutin A.A.
Experience of Using Neuroendoscopy in Treatment of Non-Communicating Hydrocephalus in Infants 57

Kheireddin A.S., Filatov Yu.M., Belousova O.B., Eliava Sh.Sh., Sazonov I.A., Kaftanov A.N., Maryashev S.A.
De Novo Cerebral Aneurysms 68

Kutin M.A., Kurnosov A.B., Kalinin P.L., Fomichev D.V., Alekseev S.N., Shkarubo A.N., Sharipov O.I., Strunina Yu.V.
The Effectiveness of a HyperHAES Hypertonic Iso-oncotic Plasma Solution in Achieving Stable Intracranial
Hypotension in Endoscopic Endonasal Transsphenoidal Adenomectomy as an Alternative to Invasive External Lumbar Drainage 74

PRACTICAL NOTES

Konovalov A.N., Konovalov N.A., Pronin I.N., Shishkina L.V., Zolotova L.I., Yakovlenko Yu.G., Korolishin V.A., Onoprienko R.A., Timonin S.Yu.
Multiple Primary Liponeurocytoma of the Central Nervous System 79

PRACTICAL GUIDELINES

Krylov V.V., Grin' A.A., Lutsik A.A., Parfenov V.E., Dulaev A.K., Manukovskiy V.A., Konovalov N.A., Perl'mutter O.A., Safin Sh.M., Kravtsov M.N., Manashchuk V.I., Rerikh V.V.
An Advisory Treatment Protocol for Acute Complicated and Uncomplicated Spine Injuries in Adults
(Association of Neurosurgeons of the Russian Federation). Part 3 88

SCIENTIFIC COMMUNITY

Pitskhelauri D.I., Bykanov A.E., Zhukov V.Yu., Kachkov I.A., Buklina S.B., Tonoyan A.S.
Current State of Surgical Treatment of Insular Gliomas 101

In accordance with the resolution of the Higher Attestation Commission of the Ministry of Education and Science of the Russian Federation, the Problems of Neurosurgery named after N.N. Burdenko was included in the List of Leading Peer-Reviewed Journals and Periodicals issued in the Russian Federation where the main results of Candidate and Doctor Theses are recommended to be published.

doi: 10.17116/engneiro201579274-78

The Effectiveness of a HyperHAES Hypertonic Iso-oncotic Plasma Solution in Achieving Stable Intracranial Hypotension in Endoscopic Endonasal Transsphenoidal Adenomectomy as an Alternative to Invasive External Lumbar Drainage

M.A. KUTIN*, A.B. KURNOSOV, P.L. KALININ, D.V. FOMICHEV, S.N. ALEKSEEV, A.N. SHKARUBO, O.I. SHARIPOV, YU.V. STRUNINA

Burdenko Neurosurgical Institute, Moscow, Russia

The structure of pituitary adenomas surgeries has been fundamentally changed over the past decade. The transnasal transsphenoidal approach is currently used to resect more than 95% of adenomas. The wide use of endoscopy has radically changed the requirements for intraoperative control of intracranial pressure. Previously, controlled intracranial hypertension was used to bring the suprasellar capsule and tumor remnants to the field of vision during microscopically controlled transnasal surgeries. However, endoscopically controlled tumor resection requires controlled intracranial hypotension in order to achieve complete spreading of the suprasellar capsule. Conventionally, external lumbar drains, which are inserted at least for the entire duration of surgery, are used to control intracranial pressure. We present the results of the study proving the effectiveness and safety of the HyperHAES hypertonic iso-oncotic plasma substitute in achieving stable intracranial hypotension according to a large body of clinical data. Our findings demonstrate that using the HyperHAES hypertonic iso-oncotic plasma substitute during standard adenomectomy eliminates the need in an invasive external lumbar drainage, while the surgery quality and associated risks remain at the same level.

Keywords: *transnasal surgery, intracranial hypotension, lumbar drainage, hydroxyethyl starch.*

Transnasal surgeries have been performed at the N.N. Burdenko Neurosurgical Institute for more than 30 years. Prior to 2006, all operations had been microscopically-controlled (with or without endoscopic assistance). More than 7,000 operations had been performed over that period of time. Since 2006, all transnasal surgeries at the clinic have been entirely endoscopically-controlled. More than 3,500 operations have been performed thus far. Approximately 70% of tumors resected using the transnasal approach are pituitary adenomas, i.e. tumors with well-defined capsules. In our practice, the percentage of tumors without suprasellar spread does not exceed 10%.

Almost from the beginning, it became clear that the transnasal approach requires control over the position of the suprasellar part of the tumor. Initially, only lumbar punctures with introduction of 20.0—30.0 mL of air were used, which allowed correlating positions of a tool and the suprasellar part of the tumor capsule using lateral craniography with an image converter. Since an operating microscope limits the operative field to the sellar cavity only, a technique of controlled intracranial hypertension was developed to improve visualization of the suprasellar parts of the tumor. The technique enables bringing the superior parts of the tumor capsule and tumor remnants down to the sellar cavity using endolumbar injection of saline via an external lumbar drainage [1, 9].

Adoption of endoscopically-controlled surgery revealed the opposite requirement: the tumor capsule bulging to the sellar cavity prevented inspecting all cavity portions, detecting and resecting tumor remnants, and reducing the risk of damage to the capsule. The simplest and most effective method of visualization of the entire surface of the tumor capsule appeared to be removal of the cerebrospinal fluid (CSF) into a lumbar drainage and achieving of intracranial hypotension without or in a combination with hyperventilation or by placing the patient in the semi-sitting position [5]. The position of the tumor capsule, depending on intracranial pressure, is schematically presented in **Figure 1**. The use of intracranial hypotension had two more advantages: the possibility of a fast reduction in venous pressure in the cavernous and intracavernous sinuses in the case of venous bleeding from them as well as the possibility of “dry” reconstructive surgery for skull base defects under conditions of intraoperative liquorrhea. Therefore, over the past 8 years, almost all transnasal surgeries were performed using an external lumbar drainage.

As an invasive technique, lumbar drainage may be associated with a number of serious complications: liquor-dynamic and dislocation complications, infectious complications, pneumocephalus, changes in the CSF composition, post-puncture syndrome, hemorrhagic complications, and direct injury. The risk of postoperative meningitis ranged from 1.2 to 8%, depending on the tumor size and surgery features [10].

Administration of a HyperHAES infusion solution (Fresenius Kabi, Germany), which is a 7.2% NaCl solution in 6% hydroxyethyl starch (HES) 200/0.5 [2, 6—8], is another variant of reducing intracranial pressure

*e-mail: Kutin@nsi.ru

used at our clinic. This plasma substitute medicine is a hypertonic iso-oncotic solution. Its osmolarity is 2,464 mosmol/L; however, in spite of this, the solution may be injected into a peripheral vein (information is available in the Vidal reference books at www.vidal.ru), which is very convenient for endoscopic endonasal transsphenoidal adenomectomy that rarely requires central venous catheterization. Because of the high HyperHAES osmolarity (especially in the case of its rapid administration), the liquid (mostly from the intercellular space) quickly moves into blood vessels and, thereby, increases the volume of circulating blood. As a result, blood pressure (BP) and cardiac output rapidly increase, and perfusion of tissues, including the brain, is enhanced. In the case of preserved autoregulation of cerebral vessels, increased cerebral perfusion pressure leads to their vasoconstriction and a reduction in brain blood filling and intracranial pressure. The HyperHAES circulating half-life, $T_{1/2}$, is about 4 h. By the beginning of the study, the medicine had been already extensively used at our clinic to reduce intracranial pressure both at different stages of neurosurgery and in critical care procedures after surgery [2, 4].

Material and Methods

A total of 84 patients aged 49.7±1.6 years were included in the study. The majority of patients, 82 (97.6%), underwent removal of various pituitary adenomas. In 2 cases, the tumor had a different histological pattern: intracapsular removal of endosuprasellar craniopharyngioma was performed in 1 (1.2%) case, and resection of chordoma was carried out in 1 (1.2%) case. Suprasellar spread of pituitary adenomas was observed in 66 (80.5%) out of 82 patients with pituitary adenomas. Endosellar pituitary adenomas occurred in 16 (19%) patients.

Tumors were removed via the standard endoscopic endonasal transsphenoidal approach [3]. Typically, the removal was intracapsular, i.e. excision of the tumor capsule was not planned before surgery.

During the tumor approach stage, all patients in the study group were intravenously injected with 250 mL of HyperHAES for 10—15 min. During the first 20 surgeries, a lumbar drainage was routinely placed to patients, as it had been placed in previous years. However, in contrast to the common practice, the drainage remained closed until the end of operation, since the tumor capsule was completely spread in all cases after HyperHAES infusion, and additional CSF drainage was not required. This rendered placement of a lumbar drainage unnecessary in all subsequent 64 operations, during which complete spreading of the tumor capsule was also observed throughout surgery.

Intracranial pressure (ICP) in the first 20 patients was continuously monitored throughout surgery by means of an invasive pressure sensor connected to a

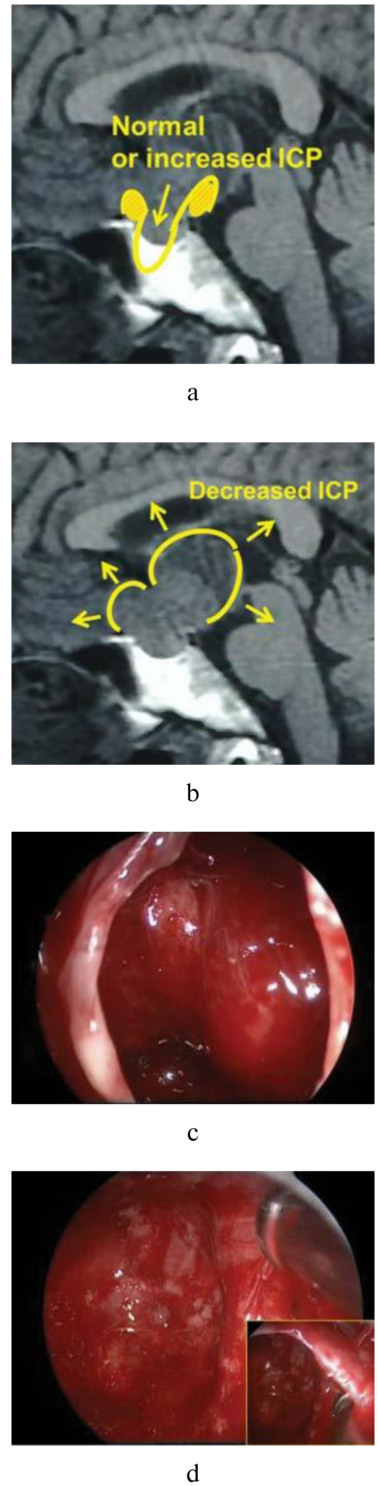

Fig. 1. **Schematic representation of a change in the tumor capsule position, depending on the ICP value.**

a — bulging of the tumor capsule into the sellar cavity associated with normal or increased intracranial pressure; b — spreading of the capsule associated with intracranial hypotension; c — intraoperative photos. The suprasellar part of the tumor capsule with tumor remnants bulging into the sellar cavity; d — intraoperative photos. Visualization of the tumor capsule cavity after its spreading and removal of tumor remnants.

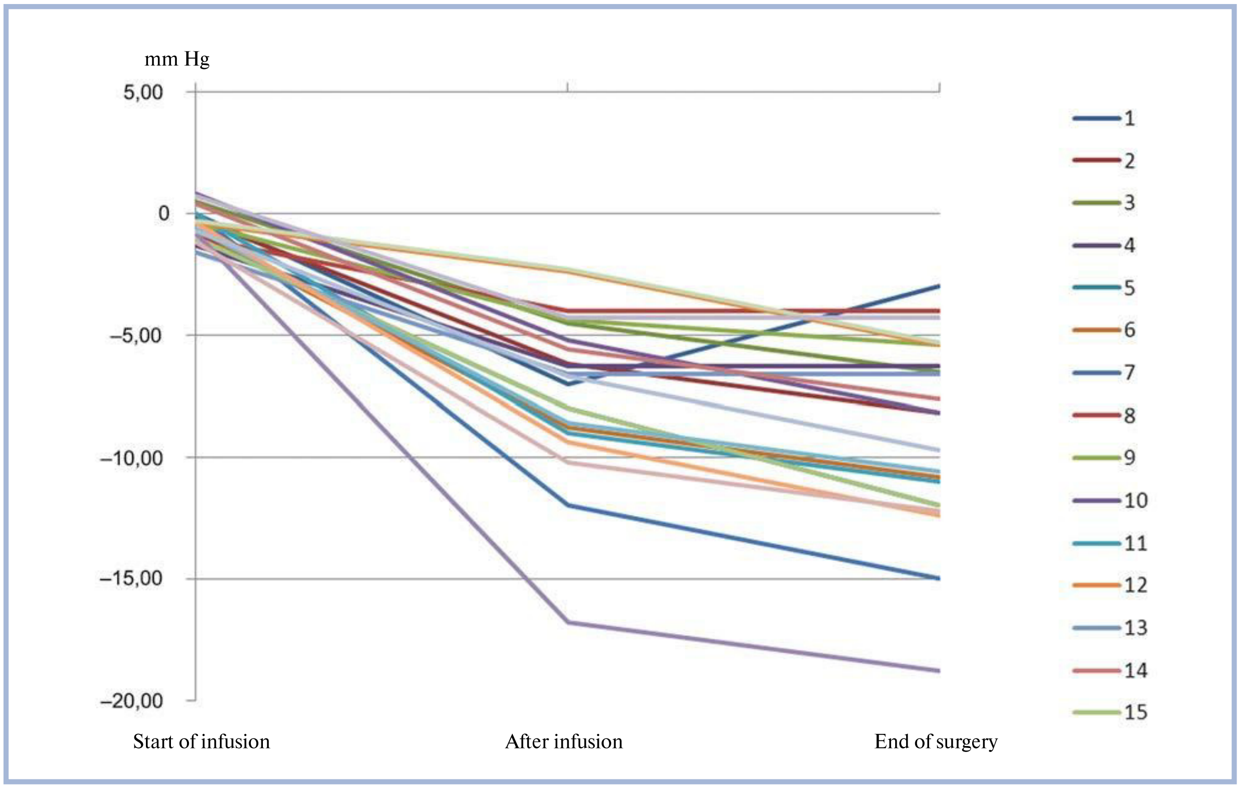

Fig. 2. **Dynamics of ICP associated with HyperHAES infusion in 20 monitored cases.**

lumbar drainage. The ICP values were recorded three times: before and after HyperHAES infusion and at the end of surgery. The lumbar drainage remained closed throughout operation. Basic hemodynamic parameters, the mean blood pressure (MBP) and mean heart rate (MHR), were recorded alongside with ICP. All patients were tested for the content of major plasma electrolytes (Na^+, K^+, cardiac glycosides, Cl^-) preoperatively, after HyperHAES infusion, and on the day after surgery. The BIS depth of anesthesia was also monitored in all patients.

Results

Hemodynamic parameters

During surgery, the hemodynamic parameters were stable within the normal range in all patients in this group. There were no significant fluctuations of the hemodynamic parameters at the primary points (before and after HyperHAES infusion, at the end of operation). The values were as follows: MBP was 94.47±1.58 mm Hg (at the beginning of infusion), 98.4±2.47 mm Hg (after infusion), and 94.01±2.56 mm Hg (at the end of operation), respectively; MHR at the primary points was 75.55±1.33, 80.9±1.44, and 77.9±1.3 per minute, respectively. A small increase in MBP (4.1%) and MHR (7%) was observed after HyperHAES infusion. It should be noted that the end of HyperHAES infusion coincided with the most painful phase of operation, approaching to the tumor, which might also affect this minor change in the hemodynamic parameters.

ICP dynamics

During ICP monitoring, a distinct ICP decrease by 8.46 mm Hg, on average, was observed **(Fig. 2)**. The ICP values were 10.96±0.7 mm Hg (before infusions), 4.27±0.98 mm Hg (immediately after intravenous infusion of HyperHAES), and 2.5±1.04 mm Hg (at the end of operation). It should be noted that, in addition to HyperHAES, other factors might affect the reduction in ICP: patient's semi-sitting position and propofol action.

After HyperHAES infusion, the electrolyte composition of plasma reversibly changed, but normalized within the first 24 hours.

Baseline electrolyte parameters

The initial preoperative plasma electrolyte levels in patients did not exceed the normal limits and were as follows: 142.95±0.55 mmol/L Na^+, 4.36±0.09 mmol/L K^+, and 105.45±0.54 mmol/L Cl^-.

Changes in electrolytes immediately after solution infusion

HyperHAES injection resulted in an increase in the Na^+ level by 5 mmol/L (on average) above the normal value and amounted to 150±0.71 mmol/L. The level of Cl^- increased by 12 mmol/L, on average, and was 118.3±1.06 mmol/L. The level of K^+, on the contrary, declined but remained within the normal range and amounted to 3.64±0.09 mmol/L. All parameters returned to the normal values with 24 h after operation.

Intraoperative monitoring

In all cases, a clear positive effect was observed: suprasellar elevation of the tumor capsule occurred, which provided conditions for full examination of all portions of the sellar cavity and removal of tumor remnants.

In all cases, the hypotensive effect retained throughout operation, and there was no need for an additional decrease in CSF pressure by lumbar CSF outflow into a drainage, which remained closed until the end of surgery.

Intraoperative liquorrhea occurred in 5 (5.95%) surgeries, but it was successfully stopped.

Postoperative monitoring

None of the patients displayed signs of postoperative liquorrhea or postoperative meningitis. Postoperative signs of hypocorticoidism associated with replacement therapy were observed in 1 patient only; hypocorticoidism was treated by increasing doses of hormonal drugs. All patients were discharged from the clinic in satisfactory condition within the standard period of time (5—8 days).

Conclusion

The study demonstrated that persistent intracranial hypotension during transnasal surgery can be provided by a non-invasive method. Laboratory tests demonstrated the safety of the method for the patient's homeostasis system. The HyperHAES plasma substitute medicine (a hypertonic iso-oncotic solution) rendered unnecessary the use of a potentially risky external lumbar drainage in ordinary transnasal surgeries that are associated with a low risk of large skull base defects and constitute the bulk of surgeries performed at the clinic.

In cases where the risk of a significant skull base defect and the need for multi-layer plastic surgery is high (e.g., in the case of extensive approaches), the use of an external lumbar drainage is reasonable and has no alternative so far.

REFERENCES

1. *Anzimirov V.L., Alekseev S.N., Voronina I.A., Krasnoperov I.V., Sokolovskaya I.E. Trunin Yu.K.* Monitoring of the blood circulation and cerebral electrical activity in conditions of controlled intracranial hypertension during transsphenoidal removal of large endosuprasellar pituitary adenomas. The 5th International Symposium, Brain injuries (minimally invasive methods of diagnosis and treatment). St. Petersburg: Nordmed-Izdat 1999; 189—192. In Russian.
2. *Israelyan L.A., Lubnin A.Yu.* Effect of a combined hypertonic-colloidal solution HyperHAES on hemodynamic parameters, indicators of oxygen transport, intracranial pressure, and cerebral oxygenation. Anesteziol i Reanimatol 2008; 2: 31—35. In Russian.
3. *Kalinin P.L., Fomichev D.V., Kadashev B.A., Trunin Yu.K., Kapitanov D.N., Alekseev S.N., Kutin M.A., Fayzullaev R.B., Shkarubo A.N., Lubnin A.Yu.* A technique of endoscopic endonasal transsphenoidal adenomectomy. Vopr Neyrokhir 2007; 4: 42—45. In Russian.
4. *Oshorov A.V., Savin I.A., Popugaev K.A., Goryachev A.S., Lubnin A.Yu., Potapov A.A.* A clinical case of the effectiveness of a HyperHAES solution in relief of intracranial hypertension in a patient with severe traumatic brain injury. Vestn Intens Terap 2010; 1: 50—54. In Russian.
5. *Aghamohamadi D. et al.* Effectiveness of lumbar drain versus hyperventilation to facilitate transsphenoidal pituitary (suprasellar) adenoma resection. Anesth Pain Med 2013; 2: 4: 159—163.
6. *Bentsen G. et al.* Predictable reduction of intracranial hypertension with hypertonic saline hydroxyethyl starch: a prospective clinical trial in critically ill patients with subarachnoid haemorrhage. Acta Anaesthesiol Scand 2004; 48: 9: 1089—1095.
7. *Berger S. et al.* Reduction of post-traumatic intracranial hypertension by hypertonic/hyperoncotic saline/dextran and hypertonic mannitol. Neurosurgery 1995; 37: 1: 98—107; discussion 107—108.
8. *Bhardwaj A., Ulatowski J.A.* Cerebral Edema: Hypertonic Saline Solutions. Curr Treat Options Neurol 1999; 1: 3: 179—188.
9. *Nath G., Korula G., Chandy M.J.* Effect of intrathecal saline injection and Valsalva maneuver on cerebral perfusion pressure during transsphenoidal surgery for pituitary macroadenoma. J Neurosurg Anesthesiol 1995; 7: 1: 1—6.
10. *Scheithauer S. et al.* External ventricular and lumbar drainage-associated meningoventriculitis: prospective analysis of time-dependent infection rates and risk factor analysis. Infection 2010; 38: 3: 205—209.

Commentary

Introduction of the endoscopic transsphenoidal technique for resection of tumors in the chiasmosellar region opened up new horizons in neurosurgical treatment of mass lesions of the aforementioned localization, particularly, pituitary adenomas. This led to a significant increase in the number of transsphenoidal surgeries, reduction in the injury rate, and increase in the radicalness and safety of these operations. However, a number of certain difficulties in performing these operations remain; one of them is hindered visualization of the resected tumor bed during bringing down the diaphragm and the superor part of the tumor capsule in the case of its suprasellar spread. One of the key techniques used to return the capsule to its "original" position was lowering of intracranial pressure (ICP) by placement of a lumbar drainage to remove a required amount of CSF. The technique worked well for many years of neurosurgical practice; however, like all invasive techniques, it has several disadvantages, including liquor-dynamic and dislocation complications, infectious complications, pneumocephalus, changes in the CSF composition, post-puncture syndrome, hemorrhagic complications, and direct injury.

The group of authors from the Burdenko Neurosurgical Institute used intravenous infusion of a HyperHAES solution (Fresenius Kabi, Germany), a 7.2% NaCl solution in 6% HES 200/0.5, in a sufficiently large group of patients and achieved good results in terms of ICP regulation; actually, they used it as an alternative to the previously used method. The study demonstrated almost complete safety of the approach, which required only monitoring of the patient's homeostasis for 24 hours.

In my view, the emergence of this non-invasive technique of lowering intracranial pressure, coupled with secondary procedures (if necessary), such as temporary anesthesia in a hyperventilation mode or moving of a patient into the semi-sitting position, can provide a good substitute for the method routinely used to reduce ICP, lumbar drainage, in endoscopic surgery for tumors with suprasellar spread. At the same time, I would recommend the authors to continue further research and develop an algorithm for unambiguous establishing of the indications for which placement of a lumbar drainage is still required or highly desirable.

A.Yu. Grigor'ev (Moscow, Russia)