MODERN SURGERY FOR NON-TRAUMATIC INTRACEREBRAL HEMORRHAGES

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In this publication, the authors present a literature review devoted to modern methods of surgical treatment of non-traumatic intracerebral hemorrhages. Currently, hemorrhagic stroke refers to a wide range of diseases of non-traumatic genesis, which are accompanied by hemorrhage into the brain substance, under its membranes and / or into the ventricular system. The relevance of the work is associated with high mortality (up to 74%) and disability (75-80%) among surviving patients with this pathology. The work presents in detail the etiology and pathogenesis of this type of cerebral circulation disorders. Surgical treatment techniques used in modern neurosurgery are described. Their positive and negative aspects are highlighted, treatment outcomes from various authors are presented. Based on these studies, indications, contraindications and criteria for selecting patients for the surgical method of treating non-traumatic intracerebral hemorrhages are determined.

Key words: hemorrhagic stroke, intracerebral hematoma, craniotomy, neuronavigation, stereotaxis, endoscopy, puncture-aspiration method, fibrinolysis.

In the structure of overall mortality, acute cerebrovascular accidents (ACVA) in industrially developed countries currently occupy the second or third place [1]. Moreover, the ratio of ischemic (IS) and hemorrhagic stroke (HS) in the structure of ACVA is approximately 70-95% versus 5-30%. Thus, the incidence of HS in the world is from 13 to 271 cases per 100,000 population [2].

Currently, HI refers to a wide range of diseases of non-traumatic genesis, which are accompanied by hemorrhage into the brain substance, under its membranes and/or into the ventricular system. Depending on the etiologic factor, HI are divided into primary and secondary. Primary HI occurs against the background of arterial hypertension (AH), it is the most common and accounts for 70-90% of all cases of non-traumatic cerebral hemorrhages [1, 3, 4]. Currently, it has been proven that with AH, a complex of morphological changes (lipohyalinosis, fibrinoid necrosis, formation of microaneurysms) occurs in the arterial vessels of the brain. This leads to deformation of the lumen of the intracerebral arteries, tortuosity of the vessels and their increased fragility. The causes of secondary GI are: rupture of arteriovenous malformation or arterial aneurysms, brain tumors, coagulo- and vasculopathies, drug use, thrombosis of intracranial veins and sinuses, chronic alcoholism, drug addiction, septic conditions, blood diseases (hemophilia,

leukemia, thrombocytopenic purpura), uncontrolled use of anticoagulants, moyamoya disease, chronic renal failure [1, 3, 4, 5].

Despite the constant development and implementation of new diagnostic and treatment methods, acute (first 3 days after the onset of the disease) mortality in GI remains very high and amounts to 38-74% [6]. Monthly mortality in GI amounts to 44-52% (for comparison, in IS it amounts to 10-15%). Disability in GI reaches 75-80% [6-9]. Meanwhile, the high level of morbidity, mortality and disability makes this problem extremely urgent [1].

The number of surgeries performed for GI varies from a complete refusal of operations to 20% of activity in different centers, but it is constantly growing every year, which is apparently due to unsatisfactory results of conservative treatment [6, 10]. Such results are explained by the fact that therapeutic treatment of GI is symptomatic, but not etiopathogenetic. Modern symptomatic treatment is aimed at normalizing cardiovascular and respiratory activity, the homeostasis system, combating the growth of cerebral edema, but does not eliminate the effects of the pathological focus. The main goal of surgical treatment is total removal of intracerebral hematoma with minimal damage to the brain [1]. This allows to eliminate the toxic effect of biologically active substances that are formed as a result of the breakdown of cells and tissues (blood, glia, neurons) - proteolytic enzymes, endothelin, serotonin, histamine, norepinephrine, etc., which leads to a decrease in the mass effect and intracranial pressure, inhibits the progression of edema and, consequently, dislocation of the brain and ischemia of the cerebral substance [1, 3, 4, 11]. Surgical treatment will be considered justified if it leads to a decrease in mortality and improves functional outcomes compared to the results of conservative treatment [11]. Currently, GI surgery is called "surgery of disappointment" in the community of neurosurgeons, since it is associated with high mortality and disability [10]. It is believed that in order to obtain the best results of surgical treatment, surgical intervention should be used only in 10% of patients with GI.

In modern surgery, a number of surgical treatment methods are used.

The puncture-aspiration method is a simple and minimally invasive method that has been used since the 1950s. The method involves aspiration of the contents of the hematoma through a burr hole. The disadvantages of the method are the impossibility of complete removal of the hematoma, since it consists of 80% clots and only 20% liquid blood [1], as well as its ineffectiveness in large-volume hematomas.

[2]. For precise targeting of the hemorrhage and acceleration of the operation, this method can be supplemented with neuronavigation [6]. Currently, this type of surgical intervention is used in patients in severe condition (coma grades II-III, hemodynamic instability) or in case of extensive hemorrhages to reduce ICP and normalize vital functions [12]. If the

patient's condition stabilizes after the operation, then radical removal of the hematoma is used.

Microsurgical (open) method - a method of removal that includes craniotomy, encephalotomy and direct removal of intracerebral hematomas. The open method is currently used in the treatment of subcortical and lateral hemorrhages, as well as hemorrhages in the vermis and cerebellar hemispheres. Surgery is performed taking into account the location and size of the hematoma, as well as functionally significant areas of the cerebral cortex [5, 6]. The advantages of the open method are a good view of the hemorrhage, rapid decompression of the brain to exclude its dislocation and intracranial hypertension.

This method is not indicated for mixed and medial hemorrhages, in which the postoperative mortality reaches 85.7% [6]. Surgical treatment is also not recommended too early after the onset of the disease, since in the first 6 hours after hemorrhage there is a high risk of re-hemorrhage. And re-hemorrhage aggravates the course of the disease and is associated with a high frequency of postoperative mortality [3, 6]. According to some authors, in order to achieve the maximum effect, one should strive to carry out surgical treatment in the first 12 hours after hemorrhage [11]. Also, some authors have proven the high efficiency of using ultrasound aspiration in hemorrhage, which improves disease outcomes and reduces the risk of recurrent hemorrhage [12]. A modification of this method is access to intracerebral hemorrhage through the Sylvian fissure (in case of mixed and medial localization), which allows to reduce mortality by 15.8% compared to conservative treatment [13]. For deep hemorrhages and hemorrhages extending into the ventricular system, transcallosal access is also used [14], which allows for a mortality reduction of 11-15% compared to conservative treatment [15]. This method involves the use of interhemispheric access and a small dissection of the corpus callosum [15]. The disadvantage of this approach is the possible formation of foci of "venous" infarctions in the postoperative period, damage to the parasagittal veins, and the development of "transient transcallosal mutism" [16]. To perform transcallosal and transylvian approaches, compared to projection encephalotomy, much more time is needed, it is necessary to master microsurgical techniques and a highly qualified neurosurgeon, therefore such surgical interventions have not become widespread.

Also, in open surgical treatment, the question of the type of operation has not been fully resolved: osteoplastic craniectomy (OPC) or decompressive (DC). It is advisable to use OPC of the skull in satisfactory and moderately severe patients, with a level of consciousness of 15-11

points, clinical manifestations of grade 1-2 dislocation, subcortical and lateral hematomas up to 30-90 cm3, with grade 1-2 intraventricular hemorrhage according to N.V. Vereshchagin, mild or moderate displacement of midline structures of the brain, mild or

moderate compression of the basal cisterns. It is advisable to use DC in severe and extremely severe condition of patients, level of consciousness of 12 points or less, clinical manifestations of grade 2-4 dislocation, volume of subcortical hematomas - 90 cm3 or more, lateral - 50 cm3 or more, mixed - 30 cm3 or more, with grade 2-3 intraventricular hemorrhage according to N.V. Vereshchagin or hemotamponade, severe compression of the basal cisterns [17]. Although, according to some publications, removal of the bone flap does not affect the level of postoperative mortality and functional outcomes [6].

In microsurgical removal of hemorrhages in the cerebellum, suboccipital-median and suboccipital-paramedian approaches are used. For additional unloading, when wedging of the cerebellum into the occipito-cervical dural funnel is observed, it can be combined with resection of the arches of the first and second cervical vertebrae and plastic surgery of the dura mater, and in some cases with external drainage of the ventricles [5].

The disadvantage of the microsurgical method of treating GI is the additional trauma to the brain tissue caused by traction and coagulation of the cortex, intersection of vessels, which leads to an increase in additional cerebral edema and dislocation of the brain and is often accompanied by a relapse of hemorrhage. And the hypoperfusion zones that form in this case lead to the development of symptomatic epilepsy and impairment of cognitive functions in the late postoperative period [18]. The long-term results of treatment with the microsurgical method are presented in Table 1.

Stereotactic method is one of the modern methods, when special equipment (MRI or CT-tomographs) is used for operations, allowing to determine exact coordinates of the area of interest of the brain with subsequent manipulations on them [22]. In such systems, brain scanning is carried out with a special localizer fixed on the head, a personal computer is used to calculate coordinates, and the target is selected on the computer monitor. This method is most appropriate to use for medial and mixed strokes. The disadvantage of the method is a more frequent relapse of hematomas than with the open method, since it is impossible to carry out thorough hemostasis stereotactically. Stereotaxis is one of the minimally invasive surgical methods of removing intracerebral hemorrhages, but its implementation requires modern expensive equipment (magnetic resonance imaging guidance, special suction, intraoperative ultrasound examination) [12, 22].

Drainage of the cerebral ventricles is a low-traumatic surgical intervention used in cerebral cerebrospinal fluid surgery in the development of acute occlusive hydrocephalus (AOH). This method can be used alone or combined with other surgical interventions, including local fibrinolysis [23]. Blood breakthrough into the cerebrospinal fluid system of the brain is observed in 30-85% of CI cases, which worsens the course and prognosis of the disease, and in some cases determines the main severity of the disease, since intraventricular hemorrhage leads to damage to the ependyma, vascular plexuses, periventricular white matter and an increase in ICP [3, 6, 7]. Nieuwkamp DJ analyzed the treatment of 343

patients with intraventricular hemorrhage and showed that the mortality rate with conservative therapy was 78%, with ventricular drainage - 58%, and with a combination of ventricular drainage with local fibrinolysis only 6%. At the same time, disability with conservative treatment is 90%, ventricular drainage - 89%, and with a combination with local fibrinolysis - 34% [24]. Additional use of fibrinolytic drugs helps to accelerate the lysis of blood clots, sanitize the cerebrospinal fluid pathways and eliminate the phenomena of AOH [23], therefore, the combination of these two methods increases the effectiveness of treatment [3, 5, 6, 24]. Since washing the ventricles with saline during hemotamponade does not free the cerebrospinal fluid from blood clots. In case of hemotamponade of the IV ventricle, the introduction of fibrinolytics into the lateral ventricles is ineffective, since the therapeutic dose of the drug is diluted by the cerebrospinal fluid of the lateral ventricles, and its concentration in the IV is insufficient for lysis of clots [4]. With ventricular drainage, the risk of infectious complications is very high: ventriculitis, encephalitis, meningitis. The main methods of preventing these complications are: exclusion of cerebrospinal fluid leakage from the surgical wound; intraventricular administration of antibiotics, constant closure of the drainage system; prolonged subcutaneous tunnel. Also, with GI, it is better to drain both lateral ventricles.

Puncture-aspiration method with local fibrinolysis. One of the varieties of the stereotaxic method in combination with local fibrinolysis. In this case, a cannula with a diameter of 2-4 mm is inserted into the hemorrhagic focus through a small trepanation hole, and then the liquid contents of the focus are first aspirated through it, after which fibrinolytic drugs are administered to dissolve blood clots [27]. Currently, there is a wide choice of fibrinolytic drugs: fibrinolysin, urokinase, reteplase, actilase, prourokinase, streptokinase [27], which are administered into the very center of the hematoma to dissolve clots [27]. After 24 hours from the start of local fibrinolysis, a control CT scan of the brain is mandatory. The use of this method is especially productive in medial and deep hemorrhages, since open surgery in these localizations leads to severe surgical trauma. The introduction of fibrinolytics is effective within 5 days from the onset of the disease. According to some authors, the use of this method reduces mortality by 2-2.5 times and improves functional outcomes by 20-30% compared to the open method of removal or conservative

therapy. The use of this method is ineffective in the case of large-volume hemorrhages and in the presence of life-threatening brain dislocation syndrome. The use of the method is limited by the high cost of fibrinolytic drugs and the need for constant CT monitoring. The disadvantage of the method is the possibility of hematoma recurrence associated with the systemic action of the fibrinolytic drug and thrombus lysis, and the ineffectiveness of use in large-volume hematomas [2]. Therefore, constant dynamic monitoring of the patient and control of the hemostasis system are necessary to prevent the systemic effect of the drug.

The first removal of an intracerebral hematoma using an endoscope was performed in 1989 by Auer. The method involves puncturing the intracerebral hematoma through a burr hole with a special multichannel trocar, through which the endoscope itself, an aspirator and other microinstruments are inserted into the hematoma cavity [8, 28]. Endoscopic surgery has many advantages, including minimally invasiveness, high blood aspiration rate, low complication rate, and better protection of brain tissue [29]. The latest generation of endoscopes allow for an enlarged image of anatomical structures with good lighting, the ability to manipulate outside the line of sight, minimally invasive removal of the entire hematoma volume and, if necessary, effective hemostasis [28]. Special dissectors, an ultrasonic disintegrator and the NICO Myriad device are used to fragment clots that exceed the diameter of the working and aspiration channels of the endoscope [30]. When visualizing the source of bleeding, hemostasis is achieved using thin mono- and bipolar electrocoagulators [8]. Surgery using an endoscope occupies an intermediate position between minimally invasive and open methods of hemorrhage removal. Currently, this method is used in the treatment of lateral and intraventricular hemorrhages, but the advantages of endoscopy over other methods have not been proven [31].

Subcortical hemorrhage is removed from the frontal, temporal, or occipital regions. Access is performed from the point closest to the hemorrhage, but taking into account the location of functionally significant areas of the brain and conduction pathways, as well as the direction of the largest diagonal of the hematoma [32]. It is recommended to remove lateral hemorrhages of small-volume (spherical) hematomas from the temporal approach, and large (cigar-shaped and ovoid) hematomas from the frontal approach [32, 33]. Removal of mixed hematomas, the area of the subcortical nuclei complicated by intraventricular hemorrhage in the lateral and third ventricles, is possible from a burr hole located 2.5 cm lateral and 4 cm anterior to Bregma (the junction of the coronary and sagittal sutures) [34]. To remove thalamic hematomas and ventricular hemorrhages, three approaches are used - from Kocher's, Keene's and contralateral Kocher's points, depending on the site of hemorrhage breakthrough into the ventricular system, localization of blood clots in the ventricles and surgeon's preferences [32, 35, 36]. Currently, there are studies showing that after removal of intraventricular hemorrhages, an effective method for preventing the development of occlusive and subsequently disorptive hydrocephalus is endoscopic performance of third ventriculostomy [32, 37]. Third ventriculostomy is recommended to be performed immediately after removal of intracerebral hemorrhage and intraventricular hemorrhage (during one surgical intervention). It can be performed from the approach through which the hematoma was removed, or (if necessary) from an additional burr hole [32, 38].

In cases of ventricular hemorrhage, this method can be combined with ventricular drainage and/or intraventricular fibrinolysis [39]. The results of endoscopic treatment of GI are presented in Table 4.

Neuronavigation method. The relatively recent emergence of neuronavigation systems (Compass, Medtronic Stealth Station, Radionics Inc, BrainLab) has opened a new direction in modern neurosurgery. This method allows for intraoperative accurate verification of intracerebral hematoma with an accuracy of up to several millimeters, while, unlike stereotaxis, the surgeon is not limited in the surgical field. This method is especially effective in surgery of deep hemorrhages and when they are located in functionally significant areas [6]. The use of neuronavigation systems can significantly facilitate the planning of surgical intervention, determine the exact localization and size of the trepanation window, reduce the time of surgery and the diameter of the trepanation window, increase the radicality of surgical intervention, and reduce the risk of damage to the main functionally significant areas and vessels of the brain [2, 6]. The technique is quite simple, but its use is currently limited by insufficient experience of surgical interventions using neuronavigation systems due to their high cost and their absence in some neurosurgical departments.

Based on the above, we can formulate modern indications for surgical treatment of hemorrhagic strokes:

1. Subcortical hemorrhages with a volume of more than 30 cm3 in a compensated and sub-compensated state - open surgery is indicated [5, 21].

2. In case of hemorrhage into the cerebellum with a volume of less than 14 cm3 and a diameter of less than 30 mm, not causing compression of the fourth ventricle, but accompanied by hemotamponade and/or acute myocardial infarction, drainage of the lateral ventricles with local fibrinolysis or endoscopic third ventriculostomy is indicated [4, 5].

3. In case of thalamic (volume more than 20 cm3) and putaminal (volume more than 30 cm3) hemorrhages in patients in a compensated and subcompensated state, puncture aspiration and local fibrinolysis are indicated.

4. In case of thalamic hemorrhage (volume more than 20 cm3) in a patient with rapid increase in dislocation syndrome, which was previously in a subcompensated and compensated state, open surgery is indicated.

5. Thalamic hemorrhage accompanied by hemotamponade and/or acute myocardial infarction - drainage of the lateral ventricles with local fibrinolysis or endoscopic removal [5].

6. Cerebellar hemorrhages with a volume of 14 cm3 or more and/or a diameter of more than 30 mm, in the presence of transverse and/or axial dislocation of the brainstem in a compensated and subcompensated state - open surgery is indicated [40].

Surgical treatment is not indicated in cases of depressed consciousness to the point of coma (8 points on the GCS or less), flaccid tetraplegia, unstable hemodynamics, and absence of brainstem reflexes [4, 11].

Before deciding to perform surgical intervention for cerebellar and subcortical intracerebral hemorrhages and/or concomitant subarachnoid hemorrhage, patients should undergo CT angiography, MR angiography, or X-ray contrast angiography to determine

inclusion of arterial aneurysms, arteriovenous malformations and clarification of surgical tactics [11].

Unfavorable factors for surgical treatment of cerebral hemorrhage include: depression of consciousness to the point of stupor and below, volume of intracerebral hemorrhage over 80 cm3, lateral dislocation of midline structures of the brain over 10 mm, mixed, medial and brainstem type of intracerebral hemorrhage, breakthrough of blood into the ventricles of the brain, presence of ventricular hemorrhage and persistent arterial hypertension [3, 6, 10, 11].

Conclusion

Thus, currently the neurosurgeon has a large number of modern methods of surgical treatment of GI (stereotaxis, navigation, endoscopy, fibrinolysis). Most of them are quite effective, contributing to a decrease in mortality, a decrease in disability and an improvement in treatment outcomes compared to conservative treatment, since they are pathogenetic. The use of a specific method depends on the type and size of hemorrhage, the patient's condition, the presence of occlusive hydrocephalus, dislocation syndrome, blood breakthrough into the ventricular system, the surgeon's microsurgical skills and his technical equipment. Thus, the problem of surgical treatment of GI is still far from being completed. It seems reasonable to conduct larger studies aimed at developing and introducing new methods for removing non-traumatic intracerebral hemorrhages to improve patient treatment outcomes.

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