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Vibration Method for Removal of Hypertensive Intracerebral Hematomas

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Abstract

Background. The issues of surgical treatment of hypertensive intracerebral hematomas are complex and far from resolved. The current trend in neurosurgery is the use of minimally invasive operations, the purpose of which is the most complete removal of the hematoma with minimal damage to the surrounding brain tissue.

Purpose of the research is to propose a new device and method for the removal of hypertensive intracerebral hematomas.

Material and methods. A blunt-ended cannula 100 mm long was used, which has a constant diameter of 10 mm over 90 mm, after which it conically narrows. At the border of the narrowing, the cannula has 3 longitudinal symmetrical oval holes 8 mm long and 6 mm wide. A micro vibration motor is located flush with the holes inside the cannula, which is an electric motor on the shaft of which there is an unbalanced load in the form of an eccentric. The device operates as follows: the truncated end of the cannula is punctured and positioned in the center of the hematoma. The vibration motor is connected to a power source with a voltage of 3.0 to 4.5 V DC. The vibration creates a limited vibrating circuit, which destroys and crushes the hematoma clots through the holes in the cannula. A metering peristaltic pump is connected to the outer end of the cannula to remove the blood clots.

Results. A new device and method for removing hypertensive intracerebral hematomas are described. Preliminary data from a pilot study showed the possibility of using the device and method in patients with this pathology.

Conclusions. A new vibration method for removing intracerebral hematomas is proposed. Further accumulation of clinical material and determination of indications for the use of the device and method are necessary.

Keywords: Intracerebral hematoma, cannula, vibrating circuit, peristaltic pump.

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1. Introduction

Hypertensive intracerebral hemorrhages (HICH), or stroke-related intracerebral hematomas (ICH), represent one of the most common and severe forms of cerebrovascular pathology [1, 2, 3]. They account for approximately 9–12% of all strokes [4, 5].

The particular medical and social significance of managing this pathology is attributable to the high rates of mortality and long-term disability [6]. Following hypertensive intracerebral hemorrhage, no more than 20% of patients return to their previous occupational activity [2, 7]. The surgical management of intracerebral hematomas remains one of the most complex and unresolved challenges in contemporary neurosurgery.

The current trend in neurosurgery is the use of minimally invasive procedures, which, in addition to saving patients' lives, aim to improve functional outcomes and reduce rehabilitation time [8, 9, 10].

At the same time, there is still no convincing evidence demonstrating the clear superiority of any particular surgical method [11].

Currently, four main methods are used for hematoma removal:

- ✓ Encephalotomy with open hematoma evacuation
- ✓ Stereotactic puncture and aspiration
- ✓ Local fibrinolysis of intracerebral hemorrhage
- ✓ Endoscopic hematoma removal

Studies show that each of these methods has both advantages and disadvantages, and many unresolved questions remain regarding both patient management strategy and the optimal choice of surgical technique for intracerebral hematoma removal [12].

Improving surgical tactics, introducing new technologies, and developing minimally traumatic operative techniques — with strict patient selection — remain key challenges in emergency neurosurgery [13, 14].

Purpose of the research

Our research aim is to develop and implement a novel device and method for the removal of hypertensive intracerebral hematomas.

2. METHODS

We developed an original device and method for intracerebral hematoma removal, for which patents of the Russian Federation were obtained:

- ➢ Utility model patent No. 230263 (dated 26.11.2024)
- ➢ Method patent No. 2835050 (dated 21.02.2025)

The device used for hematoma evacuation consists of:

- ❖ A conical blunt-ended cannula (Fig. 1, Fig. 3)
- ❖ A micro vibration motor located inside the cannula (Fig. 2, Fig. 3)

Figure 1. General view of the cannula

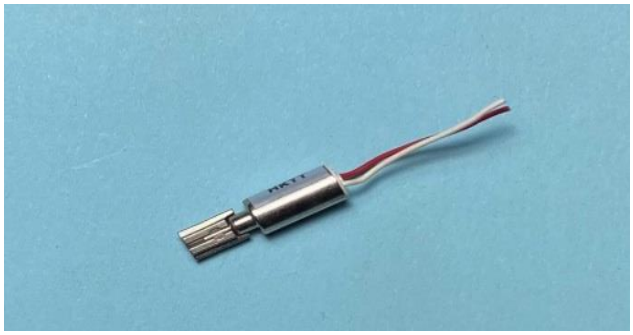

Figure 2. General view of the vibration motor

Figure 1. Oval openings

Figure 2. Eccentric mass

The cannula is 100 mm in length and made of high-quality polypropylene. For 90 mm of its length, it has a constant

diameter of 10 mm, after which it tapers conically and ends with a blunt tip.

During brain puncture aimed at accessing the hematoma cavity, the drainage channel created within the brain tissue by such a cannula is minimally traumatic, since the tissue undergoes circular stretching rather than tearing along the path of cannula advancement.

At the junction of the tapering segment, the cannula contains three longitudinal oval openings measuring 8 mm in length and 6 mm in width. These openings are symmetrically positioned at the same level along the circumference of the cannula (Fig. 1, Fig. 3).

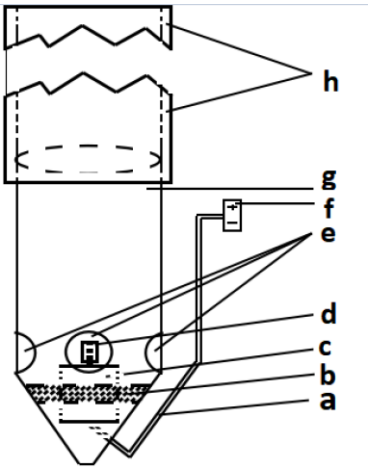

Figure 3. Schematic diagram and general view of the device for intracerebral hematoma removal, where:

a) power supply wires;

b) coupling;

c) vibration motor;

d) eccentric mass;

e) longitudinal oval openings on the cannula;

f) power source;

g) conical cannula;

h) silicone suction tube.

In the conical portion of the cannula, a micro vibration motor is positioned (Fig. 2, Fig. 3). The motor is a direct current (DC) electric motor. An unbalanced load in the form of an eccentric mass is mounted on the motor shaft (Fig. 2, Fig. 3).

This type of vibration system is known as ERM (Eccentric Rotating Mass) and is commonly used in mobile phones to generate vibration. Similar technology is also utilized in electric toothbrushes.

During operation, the localized vibrating contour generated by the motor fragments and disrupts hematoma clots. A suction system, represented by a dosing peristaltic pump (Fig. 4), is connected to the external end of the cannula via a silicone catheter (Fig. 3).

The negative pressure created by the pump, both within the hematoma cavity and inside the cannula, facilitates the aspiration of fragmented clots and their removal from the cranial cavity.

The device operates as follows: after minimally invasive access is established, the cannula is inserted into the hematoma cavity. The truncated conical tip of the cannula is positioned in the center of the hematoma. The vibration motor is then connected to a power source.

The generated vibration creates a localized vibrating contour which, through the openings in the cannula, causes fragmentation and mechanical disruption of the hematoma clots. Simultaneously, a thick-walled silicone catheter is attached to the outer end of the cannula and connected to a dosing peristaltic suction pump.

Figure 4. General view of the dosing peristaltic pump.

To prevent the risk of recurrent hemorrhage, a dosing peristaltic pump was used for suction, providing gentle hematoma aspiration at a rate of 2–8 mL/min. The system was based on the BS 100-1AQ peristaltic pump, capable of controlled aspiration of blood clots at 0–100 rpm and a pressure of 0.27 MPa (Fig. 4).

After complete hematoma evacuation, the cannula is removed from the brain.

Within this pilot study, the developed method was successfully applied in 10 patients with intracerebral hematomas aged 41–60 years (7 men and 3 women).

Level of consciousness at admission:

- Clear consciousness – 1 patient
- Somnolence – 2 patients
- Soporous state – 5 patients
- Moderate coma – 2 patients

Hematoma localization:

- Lateral – 4 patients
- Mixed – 4 patients
- Lobar – 2 patients

Hematoma volume:

- < 40 cm^3 – 1 patient
- 41–60 cm^3 – 7 patients
- 61–90 cm^3 – 2 patients

Treatment outcomes were assessed using hospital mortality rates and functional outcomes according to the Glasgow Outcome Scale.

3. Results and Discussion

Among the 10 operated patients, one death (10%) was recorded in a patient operated on in the hyperacute stage of the disease with a hematoma volume greater than 80 cm^3.

Functional outcomes were as follows:

- ✓ Good recovery – 20%
- ✓ Moderate neurological deficit – 30%
- ✓ Severe neurological deficit – 40%

The volume of hematoma evacuation reached 80–90% of the initial hematoma size. No cases of recurrent hemorrhage were observed.

Biomechanical Rationale and Safety Considerations

The proposed method is based on localized mechanical action confined to the hematoma cavity — that is, within an area of already established primary brain injury where neuronal structure is partially or completely destroyed.

Thus, mechanical impact is not directed toward intact brain tissue but is limited to the pathological focus, fundamentally reducing the risk of additional damage to functionally significant structures.

From a biomechanical perspective, brain tissue is a viscoelastic medium sensitive to high-amplitude and high-frequency mechanical oscillations. Therefore, low-amplitude exposure parameters were selected in this study (140 Hz frequency, 0.05 mm amplitude), which do not exceed mechanical stress levels encountered during standard neurosurgical procedures such as hematoma aspiration or microsurgical manipulation.

Importantly, the selected parameters do not induce cavitation or resonance effects associated with vascular or neuronal injury.

An additional safety argument is the short duration and strictly localized nature of the exposure. The mechanical action is applied briefly (no more than 5–10 minutes) and exclusively during the hematoma evacuation phase, without significantly increasing the total operative time.

The absence of prolonged exposure reduces the likelihood of triggering secondary injury cascades, including neuroinflammatory responses and delayed ischemia.

Within the framework of this study, safety is defined not as absolute harmlessness but as the absence of additional damaging effects on brain tissue compared with standard surgical intervention under the specified exposure parameters.

4. Conclusion

The proposed device is technically simple and can be used under local anesthesia, which is particularly important for critically ill patients.

This surgical technique may be performed not only in specialized neurosurgical centers but also in municipal and regional hospitals equipped with computed tomography, as well as within air medical evacuation systems.

The device differs from existing systems and may become a promising addition to the arsenal of minimally invasive neurosurgical techniques. In our opinion, it may expand both the patient population and the indications for surgical treatment of intracerebral hematomas.

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