Ultrasonic aspiration in neurosurgery

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Summary

A short review describes the equipment of the ultrasonic aspirator CUSA, the microscopic and ultramicroscopic changes of brain tissue exposed to ultrasonic aspiration, as well as the indications and clinical experience in brain tumour operations.

Keywords: Experimental and clinical experiences, ultrasonic aspiration in neurosurgery, technique.

Introduction

It is by no means unusual that instruments or techniques developed in one medical specialty outgrow their original purpose and provide excellent services to other specialties. Ultrasonic aspiration is a typical example of this phenomenon. The original idea is about 20 years old and was developed by C. D. Kelman, an ophthalmological surgeon, with the purpose of treating cataract by a procedure he named phaco-emulsification [6, 7]. In fact, this instrument was primarily designed to be an ultrasound knife. After a short time, however, neurosurgeons and general surgeons realized the tremendous potentialities of this instrument, which underwent several improvements until the present form was reached. Also, a series of clinical and experimental studies were published on ultrasonic aspiration in neurosurgery and general surgery [1, 2, 3, 4, 5, 9, 10]. It was established that ultrasonic aspiration produced no deleterious physiological effects on nervous tissue [10].

Nowadays ultrasonic aspiration may be considered part of the everyday routine of an updated neurosurgical operating theatre. By adequately setting the controls of the computer-steered aspirator, one may achieve the functions of (1st) aspiration, (2nd) cutting and (3rd) coagulation.

Description of the equipment

The ultrasonic aspirator CUSA* (Fig. 1) consists essentially of a central steering unit, a handpiece and a control pedal. The central steering unit is mobile, and the handpiece may be submitted to gas sterilization.

The handpiece (Fig. 2) contains a hollow titanium tip which oscillates longitudinally along its axis, driven by a magnetostrictive transducer. Oscillation occurs with a frequency of 23 kHz (23000 times per second), which corresponds to ultrasound. The longitudinal vibration of the titanium tip destroys cell membranes by its "hammering effect". The total extent of tip oscillation is 300 μ and may be regulated in the central steering unit.

Since the high-frequency vibration causes marked production and liberation of heat, the aspirating core is enveloped by a protecting sheath which serves for irrigation of the tip. For this purpose, physiological saline coming from a commercial infusion bottle is used. Irrigation intensity can be changed as needed in the central steering unit, the irrigation solution being propelled by a roll pump. When irrigation is kept very low, the heat developed by ultrasonic aspiration can be used for cutting or coagulating purposes. It will effectively obliterate vessels with a diameter of less than 2 mm.

Suction, which can also be regulated at the central steering unit, serves to remove the tissue fragmented by the vibrating tip as well as the irrigation through it.

The central steering unit contains the electronic circuits as well as the suction, irrigation and cooling systems. All functions are computer-regulated.

* Cavitron Corporation, Stamford, Connecticut
Tip vibration can be continuously regulated up to 75 watts, which corresponds to the maximal vibration length mentioned above.

A series of switches in the front plate of the steering unit makes its use very easy. These switches contain green and red lamps and are put in action one after the other, whenever the corresponding green lamp is on. This makes its use extremely simple.

Suction is also regulated in a continuous fashion from 0 to 60 mm Hg.

Irrigation can be regulated from 1 to 50 ml/min.

A timer records the time for which each tip has been used. The manufacturer recommends that total utilization time for each tip should not surpass 30 min, but we have been able to re-use a tip for much longer periods.

The pedal serves to trigger aspiration and/or irrigation. It works on an on/off basis and plays no role in the fine regulation of these functions.

Fig. 1. CUSA equipment. Central steering unit (background), triggering pedal (on the floor) and handpiece (on the tray).

Fig. 2. Ultrasonic aspiration handpiece for model NS-100.

Fig. 3. Seven days after ultrasonic aspiration in the rat cortex, the necrotic and haemorrhagic tissues have been cleared, the aspiration cavity shows clear-cut borders, and there is practically no surrounding oedema, as shown both by myelin stain according to Weigert (upper section) and by haematoxylin-eosin (lower section). Magnification: approx. 70×.