Portable Surgery Aspirator for Post-Surgery Drainage with Pressure Control Based on Impedance Changes

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***Abstract* – In this paper a small-scale portable aspiration system for post-surgery drain is represented together with the method of detecting the exudate in wound chamber to control device with the aim to reduce risk of damaging patients' wound chamber walls during the post-surgery period. Impedance measuring using the block of sensors is used as the method of exudate detection necessary for valuation of wound chamber filling with infiltrate and further pressure feeding control according to the measured impedance.**

***Keywords* – exudate impedance, small-scale portable suction device, mobile surgical aspirator pump**

I. Introduction

PERMANENT negative pressure formed inside the drained chamber in case of exudate absence can provoke cannula adherence to wound chamber walls and form the risk of adjacent biotissue damaging. Thus, controlled infiltrate evacuation with a possibility of switching pressure off in moments, when wound channel contains no liquid, is currently topical for post-surgery treatment of patients.

II. Problem Definition

The authors set the goal to determine the moment of exudate formation with the aim to control device operation depending on presence of the liquid inside the wound chamber. This task can be solved by sensors mounting in working section of the device. Measuring impedance in various points of cannula longitudinal section can be used as the cheapest and the simplest method.

III. Theory

Electrical circuit, which can simulate biological tissues, is a circuit containing series and parallel connection of active and reactive elements (resistors, condensers, inductors). Thus, the ac resistance of biotissue is frequency-dependent and is called impedance.

Electric impedance (complex resistance, total resistant) — is the complex resistance in a circuit that includes active and reactive resistance.

$$Z = R + jX ,$$

where Z – impedance, R – active resistance, and jX – reactive resistance

the impedance amplitude value can be determined using the formula:

$$|Z| = \sqrt{R^2 + X^2} ,$$

In practice, impedance measuring can be done using an electric circuit that provides metering amplitude values of voltage and current with further impedance calculation using the formula:

$$|Z| = \frac{U}{I}$$

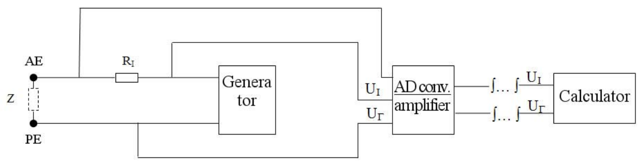

Fig. 1 — Structural chart of impedance meter.

Fig. 1 represents the impedance meter chart that will be used in the developed system. The generator forms alternate voltage and transfers it to the active (AE) and passive (PE) electrodes. The circuit contains a resistor, which measures voltage drop for indirect calculation of current in the biological liquid-based circuit. Thus, the current amplitude value can be calculated as follows:

$$I = \frac{U_I}{R_I} ,$$

where U_I - voltage measured on R_I resistor. Drop of voltage in biological liquid is equal to voltage difference $U_G - U_I$, where U_G - is the generator voltage.

Hence, the exudate impedance is:

$$Z = \frac{R_I \cdot (U_Г - U_I)}{U_I} \quad (1)$$

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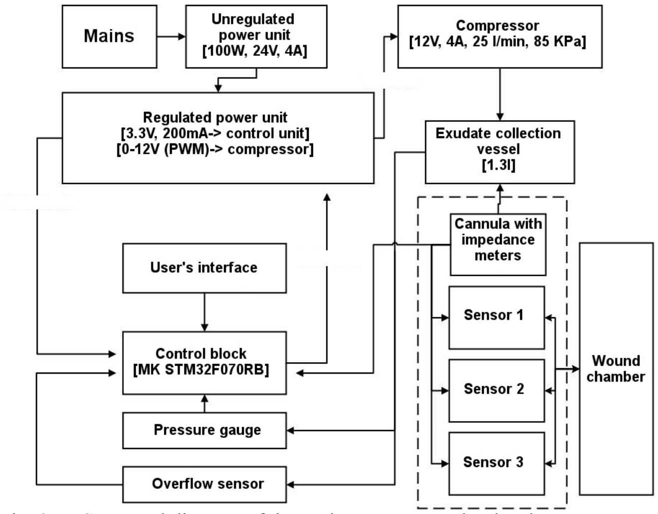

Fig. 2 — Structural diagram of the aspirator pump under development.

The general structural chart of the device, which will apply this impedance metering technique, is represented on Fig. 2. The metering electrodes will be mounted inside the inner chamber of perforated cannula. DA convertor unit generates a sinusoidal signal with frequency 10KHz and peak value of 5V C and transfers it to electrodes. The measured voltage goes via an amplifier back to the control unit in the AD convertor line, and then is transformed in binary code for further impedance calculation using the formulae (1). Hereby, when the wound channel is filled with exudate the impedance within the sensor location area decreases to some value, and this is the signal of liquid accumulation in corresponding part of the wound channel. Application of a block of sensors installed in a certain increment along the total cannula length makes possible to determine aggregate fullness of the wound channel with infiltrate. Software of the control unit will adjust trigger threshold switching on or off pressure feeding. Here, the threshold is the value of impedance measured on each sensor, as well as the amount of sensors, in which such magnitude increased to some set value. Now it is planned to use only 3 sensors in the system, and the threshold is the drop of impedance to 100 (and less) Ohm in two any sensors in one moment of time. If this condition is fulfilled, the pressure is fed, otherwise, the pressure feeding is stopped.

IV. Experimental Results

The authors performed experiments of the developed system model. 1% salt solution electrolyte placed inside a vessel equipped with impedance meters was used as the exudate model. When solution was present the measured impedance was below the 100 Ohm threshold, and thus, the condition for pressure feeding was fulfilled. When electrolyte was evacuated from the vessel with sensors, the impedance surpassed 100 Ohm value, and pressure feeding was stopped.

V. Discussion of Results

System tests performed on the model displayed that the suggested method of wound infiltrate detecting can be successfully used in surgery process.

VI. Conclusion

The suggested aspiration system will make it possible to adjust pressure formed inside the wound chamber depending on the infiltrate amount and considerably reduce risk of damaging tissues adjacent to cannula, as well as to reduce risk of pyogenic infections emergence in post-surgery periods.

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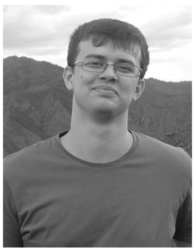

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