

## SURGICAL TREATMENT OF A GUNSHOT WOUND WITH A FOREIGN BODY: USING THE SENSITIVITY OF THE TACTILE SENSOR

**Cherniak V.A.**  
*d.med.s., prof.*

ORCID: <https://orcid.org/0009-0005-5280-542X>

Web of Science: <https://www.webofscience.com/wos/author/record/JNR-7817-2023>

Google Scholar: [https://scholar.google.com/citations?hl=uk&user=fixhR\\_UAAAAJ](https://scholar.google.com/citations?hl=uk&user=fixhR_UAAAAJ)

Biology And Medicine Institute Science Educational Center of Taras Shevchenko National University of Kyiv, Kyiv, Academician Glushkov av., 2

**Salenko O.F.**  
*d.t.n.. prof.*

ORCID: <https://orcid.org/0000-0002-5685-6225>

National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute" of the Ministry of Education and Science of Ukraine, 37 Beresteysky prospect, Kyiv, 03056

**Karpenko K.K.**  
*PhD in medicine  
з медицини*

ORCID: <https://orcid.org/0000-0002-9737-4484>

National Military Medical Clinical Hospital, Kyiv, 16 Hospitalna St., 01133

**Bondar L.V.**  
*docent*

ORCID: <https://orcid.org/0000-0002-0039-7111>

Biology And Medicine Institute Science Educational Center of Taras Shevchenko National University of Kyiv, Kyiv,, Academician Glushkov av., 2

**Pryiemyska V.O.**  
*Prokopets K.O.*

Taras Shevchenko National University of Kyiv, Kyiv, Volodymyrska, 60, 01601

*docent*

ORCID: <https://orcid.org/0000-0002-9372-0175>

Biology And Medicine Institute Science Educational Center of Taras Shevchenko National University of Kyiv, Kyiv, Academician Glushkov av., 2

**Gorya E.D.**

LLC "Bridefield-Ukraine", Kyiv, Kyiv, Reitarska St., 18/11, letter A, 01034

**Abstract.** Despite the obvious advantages of ultrasound devices, in field conditions, especially during the primary surgical treatment of gunshot wounds in patients affected by shrapnel, the device we offer has undeniable advantages, since it does not require highly qualified personnel, but is simple and energy-saving in use. Therefore, we propose to use the effect of noise emission to detect fragments. Our device should consist of 2 parts: 1) a replaceable part that is inserted into the wound; 2) a reusable device with a microphone to record noise and appropriate software for its processing. This can be used to locate the fragment in a 3-D projection, which can facilitate surgery.

**Key words:** gunshot wound, foreign bodies, detection, noise emission, surgical treatment.

### Introduction.

One of the leading causes of prolonged infection in gunshot wounds is “forgotten” fragments in the wound canal. While metal is usually easy to detect, non-radioactive elements are quite difficult to identify during primary surgical treatment.

Typically, detection methods are aimed at interaction through human tissues, using the properties of fragments such as: ferromagnetism, radiopacity. We have proven that the introduction of a probe in the form of a flexible, non-rigid elastic rod into the wound canal and touching the front part, which protrudes beyond the guide elastic-plastic tube, to the entire depth of the wound allows you to detect fragments in the wound of any density and origin, while preventing secondary suppuration of wounds. We use noise emission technology - this is the process of registering acoustic waves that arise in a material (or fabric) as a result of mechanical stress, stretching, or damage.

### **Main text.**

The device was built on the principle of changing the established vibration characteristics of a dynamic system consisting of a long elastic thread with a distributed mass, which oscillates in a viscous medium, and can contact a foreign quasi-elastic object, which is also in viscous contact with an inhomogeneous medium (the patient's body). The imposition of vibrations on the probe itself changes the conditions of contact interaction with a foreign object, and in this case, the factors that will affect the amplitude and spectral characteristics of the signal will be: 1) properties of the medium; 2) contact conditions; 3) length of the wound channel, 4) particle size; 5) elastic properties of the fragment. Based on the research tasks, the main question is the ratio of the amplitudes of oscillations of a weightless membrane at certain frequencies, in accordance with the amplitudes of oscillations from a mechanical exciter. If a mechanical vibration exciter installed in the middle of an elastic rod is in direct contact with it, the oscillation of the probing rod in a viscous medium will be determined from the following. The contact of the end of the elastic rod (probe) will affect the change in the oscillation frequencies, as well as the oscillation modes, while the presence of an elastic base (probe shell) will affect only the natural oscillation frequencies. In this case, the compression of the probe (at the moment of contact with a foreign body) will cause a change in the frequency of bending oscillations. The device consists of a housing that holds a microphone capsule with an amplifier, a flexible guide element, a probe connected to a sensitive

membrane, as well as a source of mechanical vibrations (low-frequency vibrator) fixed to the probe, which generates vibrations in the probe. Additionally, a handle-holder is mounted on the housing, an oscillographic fixing device with a board for analyzing vibrations that enter the sensitive membrane of the micro-phone capsule. Additionally, the device has two vibration sources of a certain frequency and amplitude, capable of transmitting longitudinal and transverse vibrations to the elastic flexible rod – the probe; the latter will propagate in-side the protective tube, which now becomes a means of transmitting the exciting and reflected waves from the fragment to the microphone. An experiment was conducted on biomimetics, where the dependence of the change in the oscillogram on the location of the fragment and its density was revealed. Due to this difference in noise, we were able to tactilely diagnose both metallic and non-metallic fragments. Given the location where we identified the fragments and marked them on a sterile disposable probe, like a ruler, we can fairly accurately determine the location of the fragment. To implement the above provisions, we used the program for statistical processing of experimental data "Stargraphic CENTURION". The device consists of a handle with a base and a replaceable probe/probe, which can be sterilized or sterile for single use. The device is powered by a "krona" battery. The battery must be installed correctly with respect to polarization. Before the procedure for searching for fragments, the sterilized part (probe with probe) is separated and subjected to sterilization. For this purpose, it is advisable to open the sound emission fixation chamber and carefully pull out the probe, having previously pressed the collet drive with your finger.

### **Summary and conclusions.**

In order to avoid the influence of resonance phenomena and establish rational parameters of the probe elements, the natural angular frequencies of the probe elements were determined. The solution of differential equations and the construction of transient processes of the contact moment with an elastic probe 0.3 m long showed a satisfactory convergence of the results with the data obtained experimentally. The latter were obtained based on the characteristics of the contact process of the probe of the device, with a foreign body, in the form of a glass particle measuring  $10 \times 15 \times 5$

mm and weighing 2.145 g. A mechanical device with an operating excitation frequency of 2400 - 2500 Hz and an amplitude of 0.27 mm was used as an exciter. Such a device made it possible to detune as much as possible from the frequencies of natural oscillations, and at the working end of the probe to obtain a satisfactory amplitude of oscillations, which allows improving the identification process and ensuring its reproducibility. The experiments were repeated many times, changing the contact conditions, which are generally unstable. The signal/noise ratio was estimated at frequencies of 1500–2600 Hz. The spectral density of the moment of movement of the probe probe through the wound channel remains practically unchanged and has a slightly damping characteristic in the range of higher frequencies. The oscillogram below reflects the moment of insertion of the probe into the wound channel and its further advancement with slight resistance. Inclusion of multifunctional hyperosmolar solution Reosorbilact in the infusion therapy scheme, according to our observations, contributes to achieving the goals of infusion therapy at the O, S, E stage and preventing the risks of fluid overload. The complex of means for detoxification of the wounded should include the drugs Xylate, Reosorbilact, Sorbilact. In order to prevent infectious complications, LEFLOCIN (levofloxacin) is most often used - a broad-spectrum antibacterial drug of the fluoroquinolone series with a pronounced bactericidal effect.

Were received conclusions:

1. It has been determined that non-radioactive fragments are quite difficult to detect in a gunshot wound during surgical operation.
2. It was found that the radiation obtained when the probe with mechanical excitation comes into contact with a foreign body is much more informative and allows us to indirectly estimate the size of the fragment, even if it is located in a fairly dense tissue, and the signal/noise ratio is informative up to a sensor immersion depth of 380 mm.
3. The results obtained created the prerequisites for the development, manufacture and testing of an innovative tool for inspecting wound channels to detect fragments, including those that are not radiopaque.

## References:

1. Emergency War Surgery, Ukrainian edition. This version of Emergency War Surgery (4th Ed., 2013) is being published by permission of the Borden Institute, a component of the Office of the Surgeon General, United States Army, Falls Church, Virginia, USA. EMERGENCY MILITARY SURGERY, 2022. ISBN 966-8574-05-2.
2. Ya. L. Zarutskiy, A. E. Tkachenko and M. S. Vovk, Clinical and epidemiological characteristics of inflammatory chest injuries in military servicemen during the ATO/JFO period, Kyiv, 2021.
3. V. Cherniak, O. Salenko, V. Orel, K. Karpenko and V. Pryiemska, "SOUND METHODS OF DETECTING FRAGMENTS IN THE WOUND", SWORLD-Ger Conference Proceedings, Vol. 1, No. 34-00, pp. 48-57, Aug. 2024, doi:<https://doi.org/10.30890/2709-1783.2024-34-00-009> .
4. A. Lurin et al., "Indicators of X-ray fluorescent intensity in the content of captures of metal fragiles of soft tissues in injuries with explosive and fire-fire", EMERGENCY MEDICINE, 18(3), pp. 48-54, doi: <https://doi.org/10.22141/2224-0586.18.3.2022.1491> .

*Scientific adviser: Doctor of Medical Sciences, prof. Cherniak V.A.*

*The article was prepared within the framework of the research project: "Development of an innovative portable device for detecting fragments in the wound, including non-radiographic ones" with the financial support of the National Research Foundation of Ukraine of the competition "Science for Strengthening the Defense Capability of Ukraine" (No. 2023.04/0145).*

sent: 26.08.2025

© Cherniak V.A