FUTURITY Medicine

Citation article: Grynchuk Jr F., Grynchuk F., Polianskyi I., Besaha R. The use of laser radiation to assess the bowel viability in an experiment. *Futur Med [Internet].* 2023;2(4): 4-9. Available from: https://doi.org/10.57125/FEM.2023.12.30.01

The use of laser radiation to assess the bowel viability in an experiment

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Abstract

Aims: To investigate the possibility of using laser rays scattering indicators to assess the bowel viability.

Methodology: 30 white rats. A loop of the middle part of the small bowel (SB) with the mesentery was ligated in 10 rats. A loop of the middle part of the large bowel (LB) with the mesentery was ligated in 10 rats. The width of the laser rays at wavelengths λ=0.63 and λ=0.4 μm scattering zone (WLRSZ) was measured (in millimeters) on the afferent (AP), efferent (EP) and ligated (LP) parts of the bowel's walls in the in 6 hours. Sections of bowels were taken for histological examination. The data obtained by measurements in 10 healthy animals were the control.

Results: In AP revealed morphological disorders without signs of necrosis, in EP revealed minor changes, in LP revealed necrosis. We used the ratio of the WLRSZ at wavelengths λ=0.63/λ=0.4 μm. Control ratio on SB and LB didn't differ significantly. AP ratio on SB and LB was not significantly different, but was significantly different from the control. EP ratio on SB and LB was not significantly different and did not differ significantly from the control, but differed significantly from the indicators on the AP. LP ratio indicators on SB and LB was not significantly different, but significantly different from the control, indicators on AP and EP.

Conclusion: 1. The ratio of the laser rays at the wavelengths λ=0.63/λ=0.4 μm scattering zone width is statistically significantly different in the bowel parts without deviated viability, with morphological deviations without signs of necrosis, and with necrosis. 2. Ratio indicators > 1.58 units indicate preserved viability, indicators in the range of 1.4-1.35 units indicate morphological deviations without necrosis, indicators < 1.2 units indicate bowel necrosis. 3. The determination of this ratio should be used in patients to assess its informativeness.

Keywords: Abdominal Surgery; Small Bowel; Large Bowel; Viability; Laser Rays.

Received: August 15, 2023

Revised: September 8, 2023

Accepted: November 7, 2023

Published: December 30, 2023

Introduction

Bowel viability must be determined in acute bowel obstruction, strangulated hernias, acute mesenteric ischemia, etc. [1-4]. The main way of assessing viability is visual. But this way is subjective and not reliable enough [5,6]. There are many ways to objectively assessment [6-16]. Most of them determine the intensity of blood circulation in bowel wall tissues [7-11]. But disruptions in blood circulation are not informative enough, since bowel necrosis begins in

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DOI: https://doi.org/10.57125/FEM.2023.12.30.01

the mucous membrane [11], what such ways do not detect. Therefore, the search for an effective way of viability assessment is actual.

The way of assessing changes in the parietal peritoneum during peritonitis attracts attention [17]. The way is based on the estimation of the laser ray scattering zone width on the peritoneum. Inflammatory altered peritoneum scatters the laser ray more than intact peritoneum. Therefore, it can be assumed that there will be differences of the laser rays scattering with deviation in the bowel viability.

Research Problem

The research problem, which is the basis of this study, consists in evaluating the possibility of using laser radiation to assessment bowel viability.

Research Focus

This study is aimed at an experimental comparative evaluation of the scattering of laser rays with different wavelengths on the bowel walls without viability deviations and the bowels walls with viability deviations. This study aims to evaluate the possibility of determining the bowel viability using the indicators of the laser rays scattering on the bowel's walls.

Research Aim and Research Questions

1. To evaluate the indicators of the laser rays scattering on the bowel walls with and without altered viability.
2. To study the differences between the indicators of laser rays scattering.
3. To investigate the possibility of using laser rays scattering indicators to assess the bowels viability.

Research Methodology

General Background

The bowel viability can be accurately determined only with the help of histological examinations. The data of the laser rays scattering can be compared with histological examination data. These researches should be conducted in an experiment.

Sample / Participants / Group

30 white non pedigree rats. 10 intact animals were the control group. 20 animals were a research group. Laparotomy was performed on the animals. A loop of the middle part of the small bowel (SB) with the mesentery was ligated in 10 rats. A loop of the middle part of the large bowel (LB) with the mesentery was ligated in 10 rats.

Instrument and Procedures

The width (in millimeters) of the laser rays scattering zone (WLRSZ) was measured on the afferent (AP), efferent (EP) and ligated (LP) parts of the bowel's walls in the in 6 hours. At each part, 3 measurements were performed (on different walls of the bowel). Sections of bowels were taken for histological examination after measuring the width of the scattering zone.

The data obtained by measurements in 10 healthy animals in different parts (initial, middle, distal) of the small and large bowel were the control. Laser LEDs with radiation wavelengths λ=0.63 μm and λ=0.4 μm were used for irradiation. Bowel tissues were fixed in the 10% formalin solution, dehydrated in an ascending alcohol battery, and embedded in paraffin for histological examination. Sections were made on a microtome with a thickness of 5 μm. Deparaffinized sections were stained with hematoxylin-eosin. Stained preparations were studied in a Delta Optical Evolution Pro 100 light microscope.

Inhalational sevoflurane anesthesia was used for analgesia. Animals were removed from the experiment by an overdose of anesthetic. While performing the work, the norms of conducting research in the field of biology and medicine were observed: the Vancouver Conventions on Biomedical Research (1979, 1994), the Council of Europe Convention on the Protection of Vertebrate Animals Used in Experiments and for Other Scientific Purposes (1986).

Data Analysis

Testing of the law of distribution of samples for normality was carried out using the Shapiro-Wilk test. To test the hypothesis of equality of means, the Wilcoxon test was used, since the data distribution in the samples differed from normal.

Research Results

Histological examinations in the control showed no changes in the bowels structure. Histological examinations in the AP of each bowel revealed morphological disorders without signs of necrosis (dystrophy, edema). Histological examinations in the EP of each bowel revealed minor changes (fullness of venous vessels). Histological examinations in the LP of each bowel revealed necrosis.

The results of measuring the WLRSZ on the small bowel are shown in the figure 1.

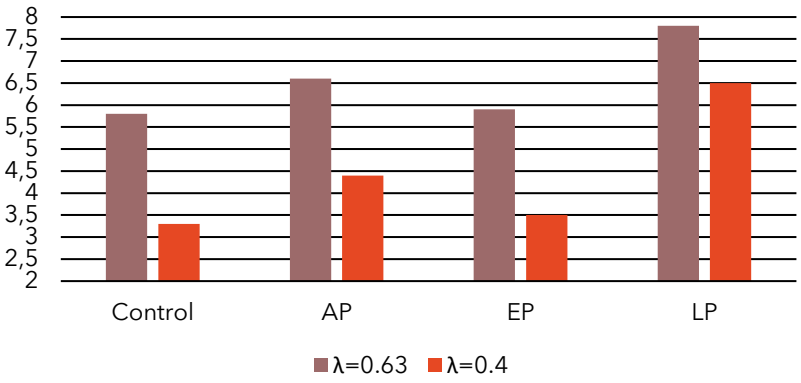

Fig. 1. The results of WLRSZ measuring (mm) on the small bowel

The results of WLRSZ measuring on the large bowel are shown in the figure 2.

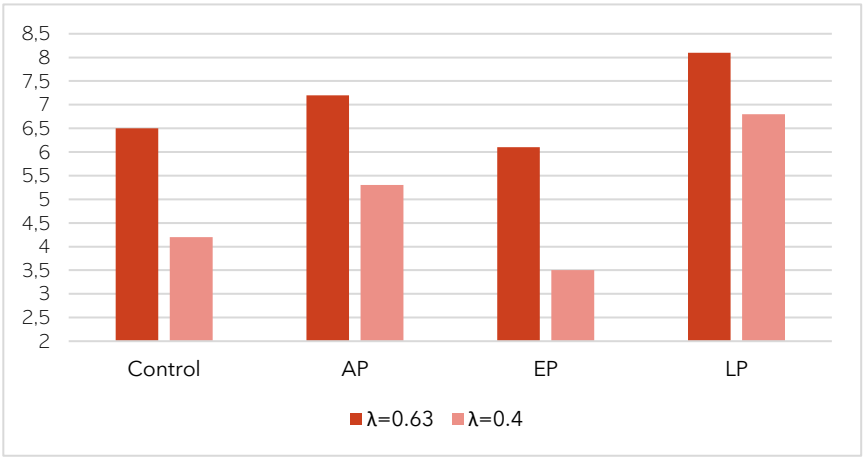

Fig. 2 The results of WLRSZ measuring (mm) on the large bowel

We also determined the ratio of width scattering zone of a laser ray with a wavelength of λ=0.63 μm to width scattering zone of a laser ray with a wavelength of λ=0.4 μm. The values of the ratio indicators are shown in figure 3.

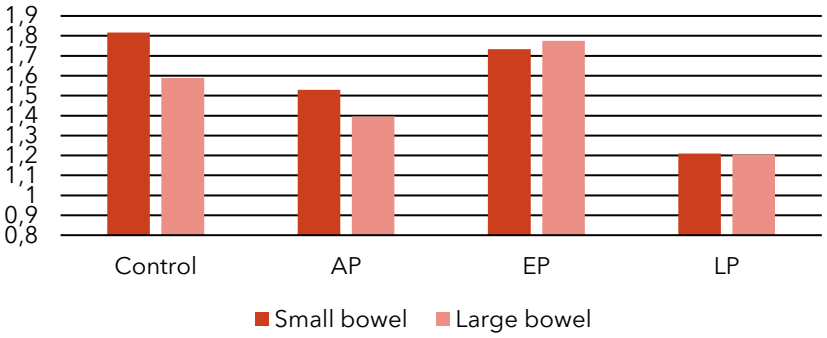

Fig. 3. The ratio of the width scattering zone of a laser ray with a wavelength of λ=0.63 μm to the width scattering zone of a laser ray with a wavelength of λ=0.4 μm

Discussion

Comparing the results of measuring the WLRSZ with the data of histological examinations shows that due to a violation of the bowel viability, the WLRSZ on the bowels walls increases. This is a consequence of the distance of the dimensions of the bowels walls structural elements h from the wavelength λ of the laser rays. The structures of the intact bowels are close to the solid state, their sizes are smaller. Therefore, these structures scatter laser rays less [18]. As a result of the bowels walls cells destruction, the cellular contents go beyond their borders, the walls become saturated with plasma, swell. The structure of the walls becomes more homogeneous. The scattering of rays is carried out by the volume, so the width of the scattering zone increases. Therefore, an increase in the WLRSZ indicates a violation of the bowel walls viability.

At the same time, absolute indicators of WLRSZ cannot be used to assess viability. This is due to the fact that the indicators of the width of the scattering zone are affected by numerous factors. Among such factors are individual differences, which are evidenced by the data distribution, which differs from the normal according to the Shapiro-Wilk test. In addition, these are local characteristics. For example, in the control, WLRSZ at wavelength of λ=0.63 μm on the small bowel was 5.8±0.25 mm, and on the large bowel – 6.5±0.31 mm ($p<0.05$). Of course, there are species differences – the indicators will differ in different animals and people, because the bowel histological structure is different. Therefore, it is advisable to use relative indicators, which can neutralize the effect of the mentioned factors.

That is why we used the ratio of WLRSZ at wavelengths λ=0.63/λ=0.4 μm. As research has shown, in the control, the ratio indicators on the small bowel (1.58±0.08 units) and large bowel (1.61±0.07 units) do not differ significantly ($p>0.05$). AP ratio indicators of the small (1.43±0.05) and large bowels (1.39±0.03 units) were also not significantly different ($p>0.05$), but was significantly different from controls ($p<0.05$). EP ratio indicators of the small (1.54±0.06 units) and large (1.67±0.07 units) bowels were also not significantly different ($p>0.05$) and did not differ significantly from the control ($p>0.05$), but differed significantly from the indicators on the AP ($p<0.05$). LP ratio indicators of the small (1.20±0.03 units) and large (1.19±0.02 units) bowels were also not significantly different ($p>0.05$), but were significantly different from the control ($p<0.01$), indicators of the AP and EP of the bowels ($p<0.05$).

Therefore, our study shows that the determination of WLRSZ ratio at wavelengths λ=0.63/λ=0.4 μm is promising for assessing the bowel viability.

Conclusions and Implications

1. The ratio of the laser rays at the wavelengths λ=0.63/λ=0.4 μm scattering zone width is statistically significantly different in the bowel parts without deviated viability, with morphological deviations without signs of necrosis, and with necrosis.

2. Ratio indicators > 1.58 units indicate preserved viability, indicators in the range of 1.4-1.35 units indicate morphological deviations without necrosis, indicators < 1.2 units indicate bowel necrosis.

3. The determination of this ratio should be used in patients to assess its informativeness.

Declarations

Author Contributions

The following statements should be used:

Conceptualization, F. Grynchuk; methodology, F. Grynchuk and R. Besaha; validation, F. Grynchuk, I. Polyanskyi and R. Besaha; formal analysis, F. Grynchuk and R. Besaha; investigation, F. Grynchuk Jr.; resources, F. Grynchuk Jr; data curation, F. Grynchuk Jr; writing-original draft preparation, F. Grynchuk Jr.; writing-review and editing, F. Grynchuk Jr, F. Grynchuk; visualization, F. Grynchuk Jr; supervision, I. Polyanskyi; project administration, I. Polyanskyi. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

- Data sharing not applicable: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Funding

Funding information is not available.

Institutional Review Board Statement

While performing the work, the norms of conducting research in the field of biology and medicine were observed: the Vancouver Conventions on Biomedical Research (1979, 1994), the Council of Europe Convention on the Protection of Vertebrate Animals Used in Experiments and for Other Scientific Purposes (1986).

Informed Consent Statement

Not Applicable.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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