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Experimental Substantiation of Application of Autoplasma to Reduce Inflammatory Response to Implants in Herniology

Serhiy H. Hryvenko[1], MD, PhD, ScD[*]; Yuriy A. Semenov[1], MD; Mariia A. Behma[2]; Abhijit Mahanta[1], MD, MS; Tamila E. Usmanova[1], MD, PhD; Andrej A. Dovgan[1], MD, PhD

[1]*Medical Academy named after S.I. Georgievsky of Vernadsky CFU, Simferopol, Crimea*
[2]*National Pirogov Memorial Medical University, Vinnytsya, Ukraine*

Abstract

The article represents an experimental assessment of the effectiveness of the author's method of processing polypropylene mesh implants during their implantation in the tissue of the anterior abdominal wall (Patent of Ukraine No. 146133). It has been demonstrated that the use of the proposed new technology for processing polypropylene mesh implants with a biocompatible component, being a simple, safe, and effective method, optimizes reparative processes in the peri-implantation zone without deteriorating the mechanical properties of mesh implants (MI). All the discovered effects make it possible to increase biocompatibility and improve the survival rate of MI. The thickness of the inflammatory shaft around the elements of MI was significantly decreased, on average, by 28.4% (P<0.05) when using autogenous blood plasma. (**International Journal of Biomedicine. 2022;12(1):134-137.**)

Key Words*:* polypropylene • anterior abdominal wall • mesh implants • autogenous blood plasma

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Abbreviations

ABP, autogenous blood plasma; **PP**, polypropylene; **AAW**, anterior abdominal wall; **MI**, mesh implants; **IC**, inflammatory changes.

Introduction

In the arsenal of surgeons, more than 300 types of mesh implants (MI) are currently used. It remains unclear why bioinert synthetic materials cause a pronounced inflammatory tissue reaction known as a foreign body reaction.[1-3] One of the main reasons for the development of periprosthetic complications is that the process of MI adaptation in soft tissues is violated as a result of poor biocompatibility and impaired formation of the periprosthetic capsule.[4-6]

Despite the fact that of the materials available in herniology, polypropylene (PP) most fully meets the requirements for anterior abdominal wall (AAW) prosthesis, it has a significant drawback – the ability to cause a pronounced inflammatory reaction from periprosthetic tissues with a predominance of the exudative-infiltrative component.[2,3] In this regard, there is a need to develop MI that cause a slight inflammatory reaction, provided that satisfactory characteristics of strength and production cost are maintained. Experimental data have appeared on the use of PP ligatures after preliminary treatment with a solution of serum albumin during implantation into muscles and for the formation of vascular anastomoses.[7] According to the researchers, this technique led to a significant decrease in the severity of aseptic inflammation around the ligatures, which made it possible to recommend it for clinical

***Corresponding author:** Serhiy H. Hryvenko, MD, PhD, ScD. Medical Academy named after S.I. Georgievsky of Vernadsky CFU, Simferopol, Crimea. E-mail: hryva@mail.ru*

use.[8] This phenomenon has been termed "suture mimicry."[7] And since PP-MI are made from the same chemical as the PP ligatures, it is advisable to study the local inflammatory response to implantation of MI treated with ABP.

The purpose of this study was experimental substantiation of the possibility and feasibility of using autogenous plasma treatment with PP-MI to reduce the manifestations of a local inflammatory reaction.

Materials and Methods

The study was carried out on 24 white nonlinear male rats weighing 200–250g. The animals were kept in the vivarium of the Department of Human Anatomy of the Medical Academy named after V.I. SI Georgievsky in compliance with the rules and international recommendations of the European Convention for the Protection of Animals (1997). The experiment was carried out in compliance with the norms of humane treatment, in accordance with the current legislation on working with laboratory animals, and was approved by the local commission on bioethics.

All animals, under ether anesthesia, were implanted with PP-MI in the AAW tissue. PP mesh "Alfa Vita 90" (Ukraine) in strips up to 1cm² was used as MI. The material was fixed in the AAW tissues with a nylon ligature from four sides. Then the wound was sutured and the integrity of the AAW was restored. The animals were divided into two groups. The main group (MG, n=12) consisted of animals that were implanted with PP-MI after treatment with ABP.[9] The latter was prepared traditionally. The exposure time was 10 minutes. The control group (CG, n=12) consisted of animals that were implanted with MI without pretreatment.

The animals were withdrawn from the experiment on Days 7, 14, 21, and 28 after implantation. After fixation in 10% neutral formaline, histological sections were prepared from the preparations according to the standard technique. Sections were stained with H&E, followed by histological and histomorphometric examination.

The results were evaluated using the Master of Morphology and SPSS computer programs.

Results

According to the data of the study, by Day 7 of the experiment animals of the CG showed a pronounced penetration of leukocytes along the circumference of the PP particles of MI. At the same time, the ontogenesis of granulation tissue along the peripheral areas was observed, accompanied by sporadic lymphocytes and histiocytes (Figure 1). When measuring the thickness of inflammatory changes (IC) in the circumference of the PP-MI fragments, this indicator was 41.607±0.279 μm (Table 1). In the MG in the same period of the experiment, leukocyte infiltration was expressed to a much lesser extent. Lymphocytes, leukocytes and histiocytes were equally represented. The natural growth of granulation tissue was formed (Figure 2). The thickness of IC in the circumference of the PP-MI fragments was 27.497±0.169 μm.

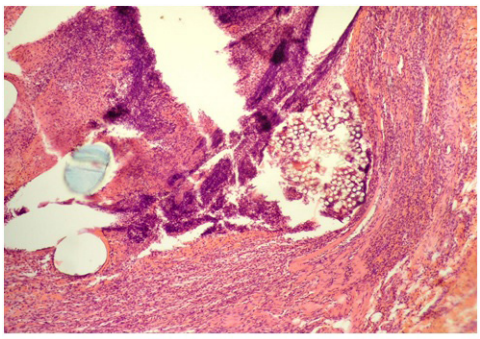

Fig. 1. *AAW of the CG animal by Day 7 of the experiment. Staining with H&E. ×10*

Table 1.

The thickness of inflammatory changes (IC) in the circumference of the PP-MI fragments (μm)

Day of the experiment	CG	MG	*P*-value
Day 7	41,607±0,279	27,497±0,169	0.000
Day 14	46,724±0,310	25,138±0,055	0.000
Day 21	40,012±0,283	23,351±0,102	0.000
Day 28	31,068±0,270	22,247±0,133	0.000

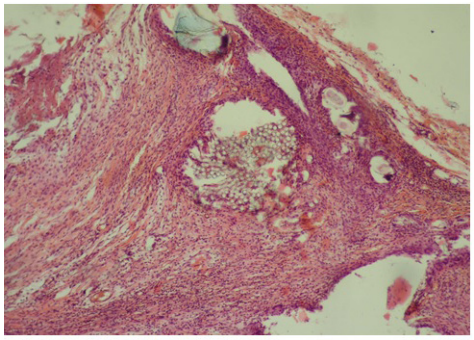

Fig. 2. *AAW of the MG animal by Day 7 of the experiment. Staining with H&E. ×10*

By Day 14 of the experiment, the animals of the CG were diagnosed with a decrease in the population of leukocytes and an increase in the number of histiocytes and lymphocytes. At the same time, sporadic siderophages were visualized, as well as giant cells of phagocytosis (Figure 3). The thickness of IC in the circumference of the PP-MI fragments was 46.724±0.310 μm. In the MG, in contrast to the CG, there was no progress in leukocyte infiltration. At the same time, giant cells of phagocytosis were not diagnosed near the PP-MI (Figure 4). The thickness of IC in the circumference of the PP-MI fragments was 25.138±0.055 μm.

By Day 21, in the CG, the inflammatory manifestations were more pronounced than in the MG. Giant cells of phagocytosis were detected near the PP-MI particles (Figure 5). The thickness of IC in the circumference of the PP-MI fragments was 40.012±0.283 μm. In the MG, giant cells of phagocytosis were also visualized. They frame the fibers of the

PP-MI yarns. In comparison with the CG, the inflammation was much less pronounced (Figure 6). The thickness of IC in the circumference of the PP-MI fragments was 23.351±0.102 μm.

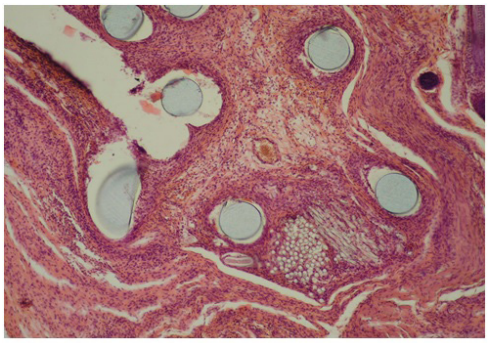

Fig. 3. *AAW of the CG animal by Day 14 of the experiment. Staining with H&E. ×10*

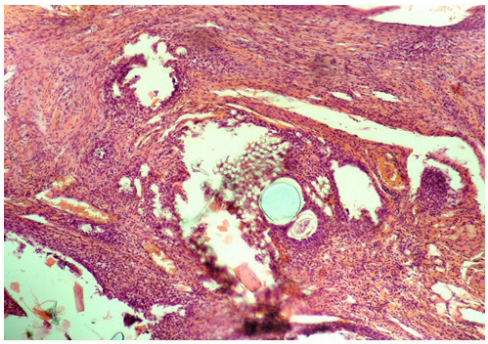

Fig. 4. *AAW of the MG animal by Day 14 of the experiment. Staining with H&E. ×10*

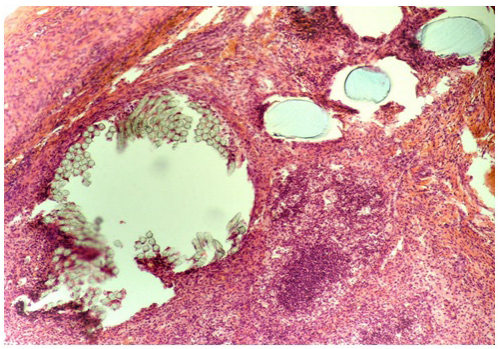

Fig. 5. *The fragment of AAW of the CG animal with elements of PP-MI. Day 21 of the experiment. Staining with H&E. ×10*

By Day 28, in the CG, intense inflammation continued to be recorded near the PP-MI filaments. Both neutrophils and lymphocytes with giant cells of phagocytosis, as well as macrophages, were visualized, as well as a significant number of siderophages (Figure 7). The thickness of IC in the circumference of the PP-MI fragments was 31.068±0.270 μm. In the MG, inflammatory processes were weakened and leukocytes were visualized, as were histiocytes, which, along with lymphocytes, were evenly represented. A fair number of giant cells of phagocytosiswere diagnosed along the circumference of the PP-MI components (Figure 8). In this case, there was a natural growth of granulation tissue. The thickness of IC in the circumference of the PP-MI fragments was 22.247±0.133 μm.

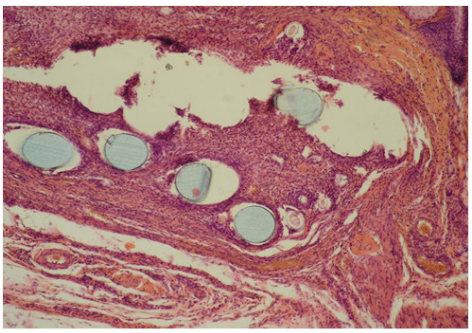

Fig. 6. *The fragment of AAW of the MG animal with elements of PP-MI. Day 21 of the experiment. Staining with H&E. ×10*

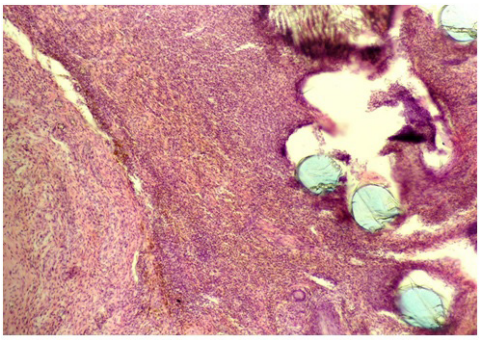

Fig. 7. *The fragment of AAW of the CG animal with elements of PP-MI. Day 28 of the experiment. Staining with H&E. ×10*

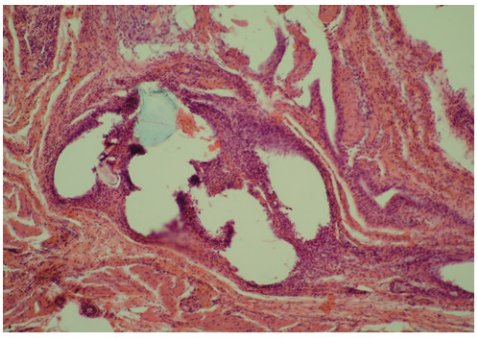

Fig. 8. *The fragment of AAW of the MG animal with elements of PP-MI. Day 28 of the experiment. Staining with H&E. ×10*

Discussion

Thus, the presented results of histological and morphometric studies confirm the fact that implantation of PP-MI causes a local aseptic inflammatory response. However, its intensity differed significantly in different experimental groups of animals at all periods of the experiment. The

greatest local aseptic inflammatory response to the implantation of PP-MI was observed in the CG, and this was true for all periods of observation. To a much lesser extent, the inflammatory reaction was observed in the animals of the MG. Thus, the technological method of treating PP-MI with an anti-inflammatory agent was experimentally substantiated; the agent proposed was ABP. The results of the conducted microscopic studies show the effectiveness of the proposed technology to reduce the local inflammatory response during the implantation of the MI-PP in the AAW tissue. The author's method for treating PP-MI with an anti-inflammatory agent can find application in herniological practice, since it is easily reproducible, and its implementation does not impose serious material requirements. Nevertheless, legal aspects remain cardinal barriers for the subsequent clinical use of the method proposed in the experiment, namely, obtaining permits (licenses) for their clinical trials.

In conclusion, treating PP-MI with ABP creates favorable conditions for their full integration into the muscular-aponeurotic layer of the AAW tissues. The thickness of the inflammatory shaft around the elements of MI is significantly decreased, on average, by 28.4% (P<0.05) when using ABP.

Competing Interests

The authors declare that they have no competing interests.

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