

Article

# Justification of the expediency of using light propylene nets for onlay plastic surgery of postoperative ventral hernias

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**Abstract:** This article discusses the feasibility of using lightweight polypropylene nets for onlay plastic surgery of postoperative ventral hernias (POVH). The study involved 137 patients with POVH, who were divided into two groups: the control group (64 patients) who underwent traditional Esfil-heavy mesh endoprosthesis and the primary group (73 patients) who received Esfil-light endoprostheses. The study investigated the clinical and immunological aspects of using propylene nets in these two groups of patients. Before surgery, the examined patients showed a suppression of the cellular link of immunity, an imbalance of the humoral link, and non-specific factors of protection. The use of polypropylene meshes (Esfil-light and Esfil-heavy) triggered an inflammatory reaction associated with the structural properties of the prostheses. However, the use of Esfil-light PP prosthesis in onlay allogenioplasty caused less inflammation in the alloplasty area compared to Esfil-heavy. Overall, the findings suggest that Esfil-light PP prosthesis can be a suitable alternative to traditional Esfil-heavy mesh endoprosthesis for onlay plastic surgery of postoperative ventral hernias. The reduced inflammatory reaction in the alloplasty area may lead to improved outcomes for patients undergoing this procedure.

**Keywords:** Ventral hernia; Polypropylene mesh; Onlay surgery; Immunological response; Allogenioplasty.

## 1. Introduction

**P**ostoperative ventral hernias (POVG) continue to be a significant challenge despite the rapid development of laparoscopic techniques [1–5]. In fact, POVG account for 22.9% of all hernia carriers, with over twenty million hernia surgeries being performed worldwide every year. However, complications specific to alloplasty have emerged, such as seroma (up to 60%), chronic postoperative pain (4–6%), and mesoma caused by mesh migration (1.2%) [6]. Additionally, the overall recurrence rate of POVG remains at 10–15% [7].

To address these complications, various types of synthetic materials have been used for alloplasty, including "heavy" mesh implants made of polypropylene (PP), "lightweight" combined mesh made of prolene and vicryl or monocryl, and mesh made of polyester threads [8]. However, many currently used synthetic materials, being foreign bodies, contribute to maintaining an inflammatory reaction in the wound due to insufficient biological inertia or inappropriate structure.

The weight of the mesh, i.e., when using light and heavy nets, and its relationship to the host tissue's reaction have not been fully investigated. It is believed that light nets cause less inflammatory reaction compared to heavy nets. Thus, the aim of this study is to compare the outcomes of using synthetic endoprostheses PP-light and PP-heavy by investigating immunoreactivity in allogenioplasty in the on-lay position.

Recently, there has been a growing body of evidence regarding the immune system's key role in the development of various diseases [8]. The development of many pathological conditions, including

postoperative complications, is based on the disruption of immunoregulatory processes in the body. However, there is limited information on the direction of the immune response, the state of cytokine production of herniological patients, taking into account the weight of the nets and their role in the wound process in the available literary and electronic sources of information. Therefore, it is necessary to investigate the implantation area of the endoprosthesis and its effect on the wound process's course by examining the dynamics of cytokine profile indicators.

## 2. Materials and Methods

This study was conducted on a sample of 137 patients who underwent surgical treatment for postoperative ventral hernias (POVH) at the clinic of the Department of Surgical Diseases of the Tashkent Pediatric Medical Institute. The patients were divided into two groups: a control group consisting of 64 patients who received the classic mesh endoprosthesis Esfil-heavy monofilament PP with greater material capacity, and a main group consisting of 73 patients who received Esfil-lung endoprostheses. To investigate the local cytokine profile and superoxide dismutase (SOD), 34 patients using Esfil-light endoprostheses and 27 patients using Esfil-heavy endoprostheses were selected for the study.

The immune system's state was assessed by measuring the expression of CD differentiation antigens. The following markers of immunocompetent cells (ICCS) were determined: CD3+, CD4+, CD8+, CD20+, and CD16+ lymphocytes. CD receptor expression was carried out in the rosette formation reaction using monoclonal antibodies of the LT series manufactured by Sorbent LLC, Russia by the method of Garib *et al.*, (1995), [9].

Serum concentrations of immunoglobulins of the three main classes A, M, and G were determined using the solid-phase enzyme immunoassay (ELISA) method with test systems of Vector Best JSC (Russia), following the manufacturer's instructions.

Pro- and anti-inflammatory cytokines (IL-4, IL-1 $\beta$ , IL-6, and TNF- $\alpha$ ) were measured in blood serum by the ELISA method using the test kits "AO Vector-Best" (St. Petersburg, Russia).

The study groups were comparable in terms of gender and age, as shown in Table 1.

**Table 1.** Distribution of patients by gender and age in groups and subgroups

Groups of patients (=137)		Control group (n=64)		Control subgroup with cytokine profile study (n=27)		Main group (n=73)		Main subgroup with cytokine profile study (n=34)		
		a6c	%	a6c	%	a6c	%	a6c	%	
Age (years)	upto 20	M	-			-				
		X	-			-				
	20-39	M	1	1,6 $\pm$ 1,6	1	3,7 $\pm$ 3,7	1	1,4 $\pm$ 1,4	1	2,9 $\pm$ 2,9
		X	2	3,1 $\pm$ 2,2	1	3,7 $\pm$ 3,7	3	4,1 $\pm$ 2,3	2	5,9 $\pm$ 4,1
	40-59	M	3	4,7 $\pm$ 2,7	2	7,4 $\pm$ 5,1	5	6,8 $\pm$ 3,0	3	8,8 $\pm$ 4,9
		X	27	42,2 $\pm$ 6,2	7	25,9 $\pm$ 8,6	29	39,7 $\pm$ 5,8	9	26,5 $\pm$ 7,7
	60-74	M	5	7,8 $\pm$ 3,4	3	11,1 $\pm$ 6,2	6	8,2 $\pm$ 3,2	4	11,8 $\pm$ 5,6
		X	24	37,5 $\pm$ 6,1	11	40,7 $\pm$ 9,6	26	35,6 $\pm$ 5,6	13	38,2 $\pm$ 8,5
	from 75 <	M	1	1,6 $\pm$ 1,6	1	3,7 $\pm$ 3,7	2	2,7 $\pm$ 1,9	1	2,9 $\pm$ 2,9
		X	1	1,6 $\pm$ 1,6	1	3,7 $\pm$ 3,7	1	1,4 $\pm$ 1,4	1	2,9 $\pm$ 2,9

The present report describes the distribution of patients in terms of the nature of their previous surgical intervention and concomitant pathology, as well as the classification of hernial defect size, to ensure that the studied groups are comparable. The data is presented in Figures 1 and 2. Specifically, Figure 1 illustrates that POVH occurred after a previously standard cholecystectomy in the majority of patients in both study groups, i.e., in 47 (31.5%) patients, which is approximately every third patient. On the other hand, Figure 2 reveals that the most common concomitant diseases were coronary heart disease, hypertension, and obesity.

In terms of immunological studies, the first stage involved the determination of a standard immunogram in peripheral blood, which allowed the determination of parameters related to cellular and humoral immunity, as well as acute phase proteins and cytokine synthesis. Blood sampling was carried out on the day of admission to the hospital, i.e., in the pre- and postoperative period. Furthermore, all patients were actively monitored through ultrasound in the postoperative period to detect any seromas or hematomas. In case of any such detection, the patients underwent puncture drainage of these exudative formations under ultrasound control. Finally, it is worth noting that the studied groups were comparable based on the nature of the operations

performed, the localization and size of the hernial defect, age, gender, and other relevant indicators. The details of the parameters are presented in Table 1.

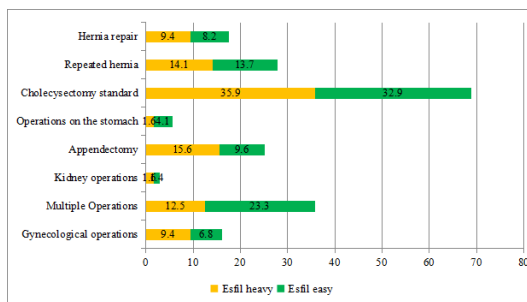


Figure 1. Distribution of patients by the nature of the previous surgical intervention

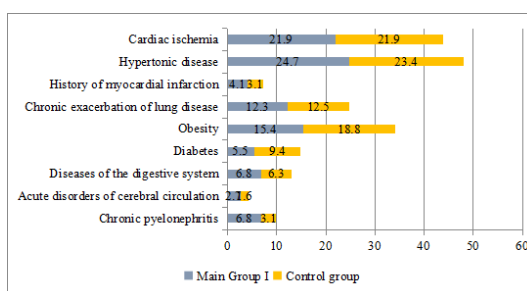


Figure 2. Distribution of patients by concomitant pathology in the compared groups

### 3. Results and discussion

It has been demonstrated that patients with POHV have multiple immune disorders related to the activity of cells of the adaptive and innate branches of immunity and cytokine production. These findings have led to a hypothesis about the direct involvement of immune mechanisms in the pathogenesis of hernia disease.

The analysis of the initial immune status in patients with POHV before surgery revealed a reduced level of the relative number of the total pool of T-lymphocytes compared to the control group ( $42.5 \pm 1.2\%$  vs.  $56.4 \pm 1.9\%$  in the control). The content of T-helper cells ( $CD4+$  lymphocytes) was significantly lower compared to the control group ( $21.3 \pm 1.1\%$  versus  $34.3 \pm 1.7\%$ , respectively,  $P < 0.05$ ), while suppressor activity was also significantly lower in the group of subjects ( $17.6 \pm 0.8\%$  versus  $21.7 \pm 1.62\%$  in the control,  $P < 0.05$ ). The imbalance of the subpopulation composition of T-lymphocytes was also reflected in the immunoregulation index, which was 1.3 times lower in patients with POHV compared to the control group. A low level of T-lymphocytes is an unfavorable prognostic sign that indicates a decrease in the effector function of T-cells. It should be noted that the absolute values are labile, as they depend on the level of leukocytes and lymphocytes. Thus, the absolute values of  $CD3+$ ,  $CD4+$  and  $CD8+$  lymphocytes were significantly higher in the group of examined patients ( $P < 0.05$ ).

The humoral branch of immunity is represented by the content of  $CD20+$  lymphocytes, as well as the immunoglobulins A, M, and G synthesized by them. The level of B-lymphocytes in patients was significantly higher, both in relative and absolute values, compared to the control group ( $P < 0.01$ ).

The results of the analysis of serum immunoglobulin content in the blood of patients showed an increase in IgG synthesis by 1.44 times compared to the control group, with a tendency to increase IgA and decrease IgM synthesis (Figure 4).

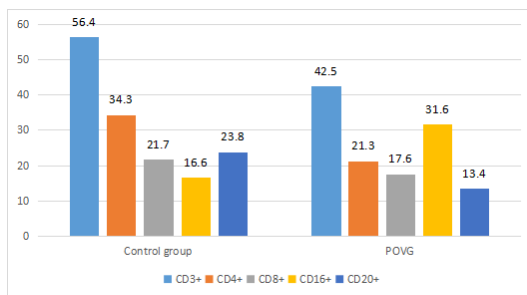


Figure 3. Relative values of indicators of T and B - system of immunity in the examined patients

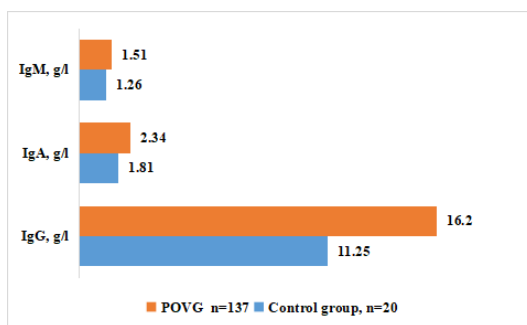


Figure 4. The level of immunoglobulins in the examined

To evaluate the state of innate immunity in the patients under examination, the quantitative content of natural killer cells (CD16+) and acute phase proteins was investigated.

Analysis of our study results revealed an increased level of absolute killer activity in the examined group by 1.3 times ( $588.1 \pm 31.2$  versus  $448.6 \pm 24.1$  in the control) and a reduced level of its relative number ( $P < 0.05$ ).

The main function of the acute phase protein system is to eliminate foreign cells and regulate the immune response.

In response to any damage to the body, protective physiological reactions develop to localize the injury and restore impaired functions, i.e., inflammation.

The obtained results suggest that the reduced level of serum lactoferrin is due to its retention of neutrophils in the focus of inflammation, which may result in a decrease in its content in the blood (Figure 5).

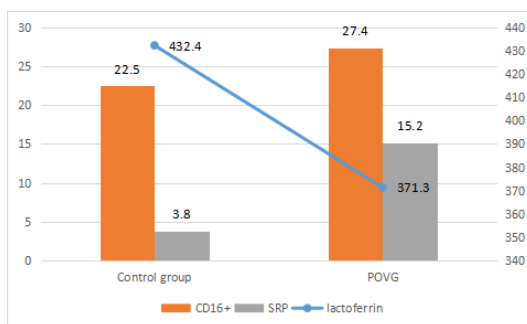


Figure 5. Indicators of acute phase proteins in the examined

The level of fibrinogen did not show significant differences between the group of examined patients and the control group.

C-reactive protein (CRP) is a predictor of complications, inhibits the anti-inflammatory properties of IL-4, and leads to a systemic inflammatory response. In the group of patients with POVH, the mean CRP value was  $7.2 \pm 0.6$  mg/L, which was 1.8 times higher than that of the control group ( $P < 0.05$ ).

The data obtained indicate that patients with POVH exhibit a pronounced imbalance in the humoral link of immunity and non-specific protection factors, especially when the T-cell composition of the immune

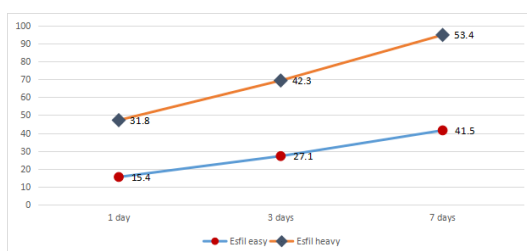
system is suppressed. Changes in general immunoreactivity were manifested by a decrease in the number of effector lymphocytes and the predominance of the Th2 type of immune response. However, the presence of concomitant pathology, particularly coronary heart disease in 30% of the examined patients, hypertension in 33%, chronic diseases of the bronchopulmonary system in 42%, and diabetes mellitus in 10%, affected changes in the overall immune response. The obtained data dictate the need for immunorehabilitation measures since a decrease in overall immunoreactivity, especially the effector link, increases the likelihood of infection with pathogenic microorganisms, disrupts the regeneration process of damaged tissues, and entails a number of complications.

The balance between pro- and anti-inflammatory cytokines plays an important role in reparative processes. According to several authors, with an individual tendency to the predominance of the pro-inflammatory component, there is a more pronounced infiltration of tissues in the wound defect area, a decrease in fibroblast proliferation, and regenerative potential. Therefore, we further studied the dynamics of pro- and anti-inflammatory cytokines in wound fluid in patients with POVH in the postoperative period.

We studied the local immunity in the postoperative period in 27 patients of the first group "Esfil-heavy" and in 34 patients of the second group "Esfil-light."

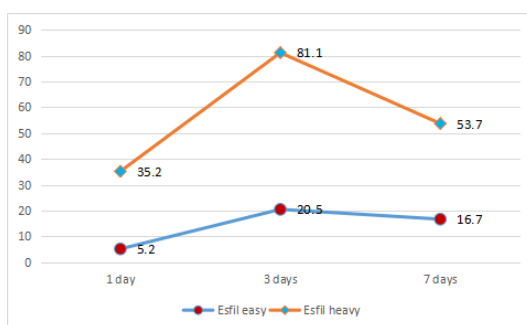
We carried out immunological monitoring of wound discharge in patients of the first and second groups (Figures 6-8).

As shown in Figure 6, on the 3rd and 7th days, there was a tendency to increase the level of proinflammatory cytokine IL-1 $\beta$ .



**Figure 6.** Dynamics of IL-1 $\beta$  concentrations in the postoperative period in the wound exudate, depending on the type of mesh used

When assessing the content of TNF-a, a statistically significant increase in this cytokine was observed in the first group of examined patients already on the first day compared to the group where Esfil lung was not implanted. The same pattern was observed on the 3rd day of the postoperative period. By day 7, TNF-a synthesis in the first group decreased to an average of  $53.7 \pm 1.6$  pg/ml. The peak concentration of TNF-a was recorded on the 3rd day of the postoperative period. In group 2, the synthesis of TNF-a increased much more slowly. The same dynamics were observed on the 7th day after surgery (Figure 7).



**Figure 7.** Synthesis of TNF-a in the postoperative period in the wound exudate in dynamics

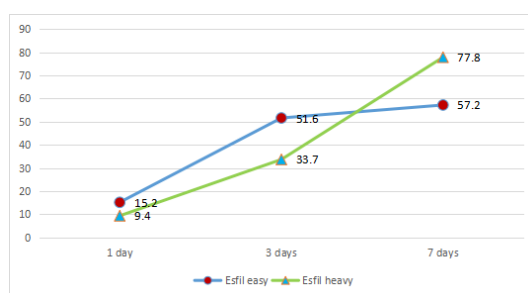
Thus, it can be concluded that the synthesis of TNF-a increases earlier and to a greater extent in group I compared to group II. The decrease in the level of this cytokine occurs simultaneously in both groups of patients, but high levels persist in the "Esfil" group.

On the first day after surgery, the synthesis of IL-6 in group II was  $32.5 \pm 5.2$  pg/ml, which was significantly lower than in group I. This pattern was observed for 3 days after the operation. By day 7, the synthesis of this cytokine had decreased by 1.43 times, indicating a pronounced inflammation that persisted longer in group I. By 3 days after the operation, the concentration of IL-6 after endoprosthetics of Esfil light was significantly lower than that of Esfil heavy.

Thus, the dynamics of IL-6 synthesis for Esfil heavy gradually increased over 3 days and began to slowly decrease by 7 days, unlike the group using Esfil light endoprosthesis.

It is known that the anti-inflammatory cytokine IL-4 is a factor in switching the synthesis of immunoglobulins from IgG immunoglobulin to IgE, as well as a key cytokine of the Th2-type immune response. It induces the activation and maturation of B cells, as well as the differentiation of Th0 into Th2-type.

In the postoperative period in group I patients, the highest concentration of IL-4 was detected in parallel with the values of IL-6 and TNF- $\alpha$ , which began to decrease by day 7 (Figure 8).



**Figure 8.** Dynamics of IL-4 concentrations in the postoperative period in the wound exudate, depending on the type of mesh used

In patients of the second group who used the Esfilm endoprosthesis, we observed a sharp increase in the concentration of IL-4 by day 3, followed by a smooth upward trend, indicating a more adequate balance of intercellular interaction. Starting from day 3, we observed a decrease in the synthesis of the studied proinflammatory cytokines TNF- $\alpha$  and IL-6, indicating a decrease in the level of local inflammation, which was more pronounced in group II. It should be noted that the level of IL-1 $\beta$  remained elevated in both groups of patients with POVH for 7 days after surgery.

In summary, based on the clinical and laboratory studies conducted, it can be argued that the intensity of immunological reactions seems to have a positive relationship with an increase in the total amount of polypropylene, not just an increase in the contact area. Therefore, the survival rate and effectiveness of using the polypropylene mesh Esfil light is more justified than the Esfil heavy mesh.

The objectives of the following studies are to analyze the immediate and long-term results of allogernioplasty in the onlay position in patients with postoperative ventral hernias using Esfil-light and Esfil-heavy meshes

#### 4. Conclusion

1. Our studies have revealed characteristic features of the state of systemic immunity in patients before surgery, including an increase in the levels of CD20+, IgG, IgA, and CRP, as well as a decrease in the levels of CD3+, CD4+, CD16+, and LF.
2. The use of polypropylene meshes, including Esfil-light and Esfil-heavy, is associated with an inflammatory reaction characterized by a stepwise increase in both pro- and anti-inflammatory cytokines, which is likely related to the structural properties of the prostheses.
3. Our findings suggest that the use of the Esfil-light PP prosthesis in allogernioplasty in the onlay position may be associated with a less inflammatory reaction in the alloplasty area compared to the Esfil-heavy prosthesis.

**Author Contributions:** All authors contributed equally to the writing of this paper. All authors read and approved the final manuscript.

**Conflicts of Interest:** "Authors declare that they do not have any competing interests."

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