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The Use of Diamond - Like Carbon Coated Surgical Polypropylene Meshes for Incisional Hernia Repair.

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ABSTRACT

Application of diamond-like carbon (DLC) coated surgical polypropylene meshes compared to similar prostheses without coating at surgical incisional hernia repair enables to decrease intensity of local inflammatory reaction in the operation area; this is defined by decreasing of proinflammatory cytokines concentration in the drainage liquid (in DLC and PP groups, respectively, – IL 1β – 109.21±21.51 and 180.2±30.6 pg/ml, p=0.016; IL 2 – 40.15±5.56 and 86.2±7.3 pg/ml, p=0.014; IL 6 – 924.18±57.16 and 1960.3±160.4 pg/ml, p=0.001; IL 8– 430.16±61.54 and 690.2±90.6 pg/ml, p=0.045). In group of DLC patients versus PP group, within the post-operative period, frequency of seroma formation after drains removing is authentically lower (DLC – 9-12%, PP – 18-34.6%, p<0.05).

Keywords: hernia mesh repair, diamond-like carbon, cytokines, seroma.

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INTRODUCTION

For the moment, application of meshes for plastics of defects at the anterior abdominal wall in patients with incisional hernia is considered to be a "gold standard" in herniologie [1]. Until recently, the problem of the fact that prostheses provoke unfavorable events for operation was not under discussion. Nevertheless, after the first successful trial of synthetic materials application, it is time for serious study of interconnection mechanisms between implant and organ tissues as well as of nature of regeneration process [2-4]. Body reaction to implant is mainly determined by its surface behavior: chemical composition, structure and morphology [5]. In this regard, existing ways for regulating biological properties of medical goods are intended for changing physical and chemical properties of the surface by using physical, chemical and physical-and-chemical methods of modification. Diamond-like carbon coating meets these requirements to a full degree. Thanks to its high hardness, low friction factor, chemical inertness and good biological properties, diamond-like carbon meshes are used for covering implants being in contact with blood (heart valves, blood vessels prostheses, stents) and operating at great loads (major joints prostheses, tooth implants, etc.) [6].

METHOD

Clinic investigation was pursued based on St. Joasaph Belgorod Regional Clinic Hospital (Belgorod, Russia). 127 patients with incisional hernia were watched. The main group comprised 75 patients having endoprosthesis replacement with diamond-like carbon (DLC) meshes. The control group comprised 52 patients with anterior abdominal wall plastics with standard polypropylene (PP) meshes. All the patients had herniotomy with "tension free" plastics and "in lay" mesh position.

In order to evaluate local inflammatory reaction within the operation area, in the drainage liquid one evaluated cytokines TNFα, IL 1 β, 2, 6, 8, 10 and IL 1 RA production at the 1st, the 3rd, and the 7th day after operation. The drainage liquid was collected into the discarded vacuum systems BD Vacutainer® (USA). Cytokines concentration was estimated at the certified microplate photometer SUNRISE (Tecan, Austria).

MAIN PART

Comparative evaluation of drained quantity from subcutaneous fat in patients from the groups under study within the post-operative period, has detected distinct differences. In the control (PP) group, term of liquid outflow from the drains made 5.01±0.9 days, in DLC group – 3.14±0.2 days ($p<0.05$). Estimation of cytokines production in the drainage liquid in patients after surgical incisional hernia repair at the 1st day after operation showed that the both groups are featured by high concentrations of proinflammatory and anti-inflammatory cytokines (Table 1). At this, IL 2 and IL 6 in the main (DLC) group show lower concentrations than in the control (PP) one. Conversely, anti-inflammatory cytokine IL 1 RA concentration is much higher in DLC group. Following differences in dynamics of cytokine profile in the groups under study were more and more distinct. It was featured by graded lowering of proinflammatory cytokines IL 1β and IL 8 concentration in patients from DLC group, at relative stability of their levels in the control group within the whole watching term.

Table 1: Estimation of cytokines production in the drainage liquid in patients from the groups under study within the post-operative period

Cytokine	1st day		3rd day		7th day	
	Control group (PP)	Main group (DLC)	Control group (PP)	Main group (DLC)	Control group (PP)	Main group (DLC)
TNFα	20.1±2.8	23.0±3.13	19.8±3.2	22.61±5.14	23.6±4.8	25.55±3.82
IL 1 β	260.8±29.2	220.75±25.0	240.6±40.6	130.39±23.09*	180.2±30.6	109.21±21.51*
IL 2	92.68±9.39	43.27±6.7*	96.5±10.1	36.75±7.73*	86.2±7.3	40.15±5.56*
IL 6	1200.3±48.1	926.34±25.48*	1464.1±108.1	924.06±66.58*	1960.3±160.4	924.18±57.16*
IL 8	674.2±90.2	570.01±59.89	704±88.6	474.32±112.23*	690.2±90.6	430.16±61.54*
IL 10	61.12±11.6	52.92±8.49	60.2±11.8	68.56±15.89	51.4±16.5	79.55±17.93
IL 1 RA	2200.3±210.4	3982.5±129.09*	1080±101.43	3690.3±264.06*	700.6±86.2	4146.8±359.30*

Note: * - authenticity of average values in the groups within the equal time periods, $p < 0.05$.

Proinflammatory cytokine IL 6 concentration in the control (PP) group was gradually increasing; in the main group, it remained almost invariable within all the watching terms. At relative stability of IL 10 concentration in patients form the control group within all the watching terms, its level has slightly increased in the main group. IL 1RA concentration in DLC group exceeded its concentration in the PP group at the 1st day after operation. At the 3rd day, it decreased abruptly in patients of PP group; in DLC group, at the 7th day, IL 1 RA concentration reaches maximum values.

After drains removing, seromas are detected at 18 patients (34.6%) in the control (PP) group, and at 9 (12%) – in the main group.

DISCUSSION

High use of synthetic meshes at incisional hernia repair became a reason for appearing of a range of complications in the post-operative period specific just for this kind of operations. One of these complications are seromas which formation frequency makes 20.9-49.2% cases. The base for seroma formation is an inflammatory reaction associated with foreign material (implant) enthesis. At this, inflammation nature and intensity is determined as complex of physical and chemical properties of material, its weight and geometry, as well as nature and physiological and biochemical properties of host responses [7-9]. After enthesis, implanted materials quickly (within few seconds) absorb protein layer of the patient before initial signs of cell response are visual. In the whole, it is considered that phagocytes have greater interaction with these spontaneously absorbed proteins than with the material itself. Immunological activity of proteins destructed after absorption favors to activation of the adherent phagocytes [5]. Just because of it, in the recent times, the greatest interest was provoked by different ways for regulating biological properties of medical goods designed for their surface modification. Development of full and adequate inflammatory reaction in the organism provides special mediators – cytokines. They perform negative and positive regulation of inflammation; they are also factors for phases changes of the inflammatory process [10, 11]. Estimation of cytokines production in the drainage liquid in patients from groups under study after endoprosthesis replacement of the anterior abdominal wall has detected rather serious differences: authentically lower level of IL 2, IL 6 proinflammatory cytokines and authentically higher level of IL 1 RA anti-inflammatory cytokine in the main (DLC) group compared to the control (PP) group. This gives us opportunity to consider that inflammatory reaction intensity within the implantation area using the diamond-like carbon (DLC) surgical meshes is authentically lower than in the control (PP) group of patients.

CONCLUSIONS

Application of diamond-like carbon coated surgical polypropylene meshes compared to similar prostheses without coating (PP) at surgical incisional hernia repair enables to decrease intensity of local inflammatory reaction in the operation area; this is defined by decreasing of proinflammatory cytokines concentration in the drainage liquid. In DCL group of patients compared to PP group within the post-operative period, frequency of seroma formation are drains removal is authentically lower.

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